VOL. 75 NOVEMBER 1952

TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA

INCORPORATED

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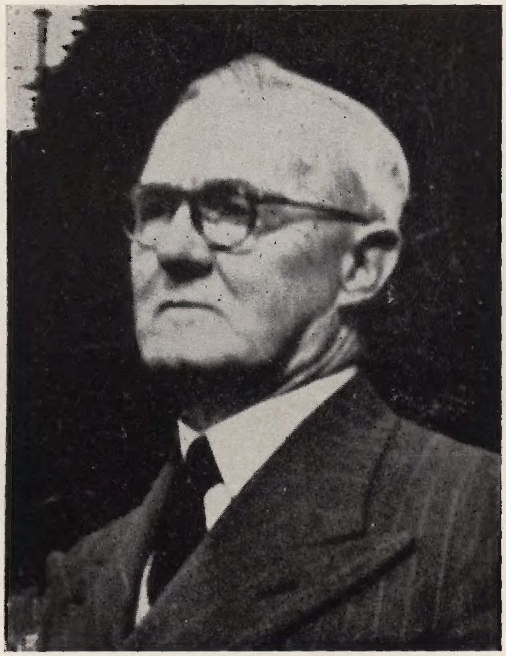

Professor Thomas Harvey Johnston

TRANSACTIONS OF THE ROYAL SOCIETY OF SOUTH AUSTRALIA INCORPORATED

PROFESSOR THOMAS HARVEY JOHNSTON

Professor T. H. Johnston, M.A., D.Sc., while still actively engaged as head of the Department of Zoology at Adelaide University, passed away suddenly on 30th August, 1951, when in his seventieth year. His death is a loss that will be greatly felt, more especially in the field of parasitology.

In his youth he had studied under the world-famous zoologist, Professor W. Haswell, and then continued throughout a long and active life to successfully devote his energies to research, resulting in many outstanding contributions to Australian science. He published some 299 papers,* mainly dealing with parasitology and, to a lesser extent, entomology.

Thomas Harvey Johnston, son of Thomas Johnston, was born in Sydney on 9 December 1881. He graduated at Sydney University Bachelor of Arts (1904) and Bachelor of Science (1906); later Master of Arts (1907) and Doctor of Science (1911). He was lecturer in Zoology and Physiology at the Sydney Technical College (1907-1909), and later was Assistant Microbiologist in the Bureau of Microbiology, New South Wales Health Department, Sydney (1909-1911).

When the University of Queensland was initiated he was appointed lecturer in Biology (1911), and later became Professor when provision was made for the Chair of Zoology (1919). As a member of the Prickly Pear Travelling Commission, he undertook investigations into the control of that menace which was taking toll of vast areas of Queensland. The conduct of this work took him around the world twice, in the period 1912-1914, in search of parasites to check the spread of the pest. From this investigation followed the introduction of the cochineal insect which ultimately led to the control of prickly pear and so to the lasting benefit of Queensland. For this achievement he obtained the Walter and Eliza Hall fellowship in Economic Biology. He was appointed Controller of the Commonwealth Prickly Pear Laboratories (1920-1923).

In 1922 he was appointed to the newly created Chair of Zoology in the University of Adelaide, and continued to occupy it with distinction until the time of his death.

In the years that ensued, Professor Johnston made the best use of the very limited resources available to build up an active Department of Zoology at Adelaide in which, in addition to maintaining the teaching programme, he had to cope with the demands of the rapidly growing numbers of medical and science students. He and his limited staff of assistants succeeded in maintaining a steady flow of research publications.

Though helminthology, in which he became a world authority, did occupy first place in Harvey Johnston's research, he inherited from Haswell a great interest in marine life, and was easily persuaded to join, as Chief Zoologist, the staff of the British, Australian, New Zealand, Antarctic Research Expedition. He was thus engaged on the two Antarctic cruises of "Discovery I" during the period 1929-1931. Throughout the duration of these operations, both in the Antarctic and Sub-Antarctic, Johnston worked assiduously and unsparingly. The scientific reports of the Expedition owe a great deal to his labour in connection with the preparation and editing of the biological reports. He himself, and jointly with certain of his graduates, contributed a number of papers to the zoological reports; the last, dealing with *Cephalodiscus*, appeared only about one week prior to his death.

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* A complete list of titles of these is available for reference at the Barr Smith Library of the University of Adelaide.

Professor Johnston also contributed to the successful publication of the biological reports of the Australasian Antarctic Expedition of 1911-1914, for in the case of the later volumes he undertook the editing earlier begun by Professor Haswell.

He was an active member of the Anthropological Society of South Australia and between the years 1929 and 1937 participated in several of the University field investigations among the natives of Central Australia.

During recent years he was a member of the Advisory Committee on water supply to the Minister of Public Works; advising on matters relating to the maintaining of purity in the city water supply.

His long association with the South Australian Museum deserves special mention. Soon after appointment on the staff of the Adelaide University he became actively interested in the work of the South Australian Museum in the capacity of Honorary Associate. He was elected by the Royal Society of South Australia as a member of the Board of Governors of the Public Library, Museum and Art Gallery of South Australia, and as the Society's representative sat on that Board from May 1927 until September 1929. On the death of Mr. Edgar R. Waite in 1928 he became Hon. Director of the Museum and worked in that capacity for about three years.

In 1931 he was elected to the Board of Governors by the University of Adelaide, and continued as a University representative until the composite Board was disbanded in January 1940 and the three institutions became separate Government departments, each with its own Board.

During the final five years of joint control Professor Harvey Johnston was Chairman of the Museum Committee. He had urged for a long time the desirability of separate control for the respective institutions, and when the care and control of the Museum were delegated to an independent Board in 1940 he was appointed Chairman by the South Australian Government and retained this office until the time of his death.

His activity in the work of Scientific Societies was widely recognised: as President of the Queensland Royal Society (1915-16), Biological Section of A.N.Z.A.A.S. (1923), S.A. Royal Society (1931-32), S.A. Entomological Society (1935-37), S.A. Anthropological Society (1937-38). Also corresponding Member of the Zoology Society (London), the N.S.W. Royal Society, the Washington Helminthological Society, and the American Association of Economic Entomology (as foreign member). He was member of the board of editors of the Australian Journal of Experimental Biology and Medical Science.

For his contribution to science he was awarded the David Syme Memorial Medal (1913), the King's Polar Medal (1934), the Sir Joseph Verco Medal of the Royal Society of South Australia (1935), and the Mueller Memorial Medal of the A.N.Z.A.A.S. (1939).

So has passed an indefatigable and remarkably thorough scientific worker, who pioneered in many fields of observation in these southern lands. He will be remembered for his quiet mien and sterling character: considerate and helpful to the many students who have passed through his hands.

He is survived by Mrs. Johnston (nee Alice Pearce) and one daughter, Mrs. W. W. Jolly (medical practitioner). His only son, J. H. Johnston (medical practitioner), predeceased him by several years.

An account of his association with the medical profession will appear in *The Medical Journal of Australia*, and his natural history activities in the *South Australian Naturalist;* both contributed by Professor J. B. Cleland.

DOUGLAS MAWSON

LIST OF TITLES OF THE PUBLISHED WORKS OF THOMAS HARVEY JOHNSTON, M.A., D.Sc.

(late Professor of Zoology at the University of Adelaide)

The following abbreviations are used in this list:

T.R.S., S.A.	=	Trans. Roy. Soc. S. Aust.
P.R.S., N.S.W.	=	Proc. Roy. Soc., N.S.W.
P.L.S., N.S.W.	=	Proc. Linn. Soc., N.S.W.
P.R.S., Qld.	=	Proc. Roy. Soc., Qld.

1. Notes on some Australian parasites. Agr. Gaz., N.S.W., **20**, 1909, 581-584. Reprinted in Jour. Trop. Vet. Sci., **5**, 1910, 349-353.
2. Descriptions of new Haemoprotozoa from Australian birds, etc. P.R.S., N.S.W., **43**, 1909, 75-96 (with Cleland).
3. On a new melanin-producing Haematozoon from an Australian tortoise. P.R.S., N.S.W., **43**, 1909, 97-103 (with Cleland).
4. On a new reptilian cestode. P.R.S., N.S.W., **43**, 1909, 103-116.
5. On some Haemogregarines from Australian reptiles. P.L.S., N.S.W., **34**, 1909, 400-410.
6. On Australian Chaetognatha. Rec. Aust. Mus., **7**, 1909, 251-256.
7. On a new Haemoprotozoon. Rec. Aust. Mus., **7**, 1909, 257-259.
8. On a cestode from Dacelo gigas. Rec. Aust. Mus., **7**, 1909, 246 250.
9. On a new species of Aphrodita. Rec. Aust. Mus., **7**, 1909, 241-245.
10. Notes on Australian Entozoa, I. Rec. Aust. Mus., **7**, 1909, 329-344. (Part reprinted in Jour. Trop. Vet. Sci., **5**, 1910, 353-357.)
11. The Entozoa of Australian Monotremata and Marsupialia, I. P.L.S., N.S.W., **34**, 1909, 514-523.
12. Notes on some parasitic Protozoa. P.L.S., N.S.W., **34**, 1909, 501-513 (with Cleland.)
13. On a new genus of bird cestodes. P.R.S., N.S.W., **43**, 1909, 139-147.
14. The potato blight (with Tidswell). Agr. Gaz., N.S.W., **20**, 1909, 809-810; and Farmers' Bulletin, No. 27, N.S.W. Dept. Agr., 1909.
15. On the rôle of water in the spread of human Helminthiasis. Aust. Med. Gaz., 1909, 479-481.
16. Certain fungoid diseases of the potato. Agr. Gaz., N.S.W., **20**, 1909, 998-1012 (with Tidswell); and Farmers' Bulletin, No. 31, 1909.
17. Notes and exhibits (of Entozoa, etc.). P.L.S., N.S.W., **34**, 1909, 117-118, 217-219, 412-413, 417-418, 590-591, 70-711.
18. Notes and exhibits (of Entozoa, etc.). P.R.S., N.S.W., **43**, 1909. Abstracts pp. xv-xvi, xx, xxviii, xxix.
19. On the anatomy of Monopylidium passerinum. P.R.S., N.S.W., **43**, 1909, 405-411.
20. Diseases of banana plants. Agr. Gaz., N.S.W., **20**, 1909, 845-746 (with Tidswell).
21. Maize smut. Agr. Gaz., N.S.W., **21**, 1910, 43-44.
22. Worm nests in cattle due to Filaria gibsoni. Preliminary report. Agr. Gaz., N.S.W., **21**, 1910, 173-174 (with Cleland); also in Jour. Trop. Vet. Sci., **5**, 1910 520-521; and also in Jour. Meat and Milk Hygiene, **1**, (1), 1911, 21-23.
23. Brown rot of fruit. Agr. Gaz., N.S.W., **21**, 1910, 194-195.
24. Worm nests in Australian cattle due to Filaria gibsoni, with a note on similar structures in camels. P.R.S., N.S.W., **44**, 1910, 156-171 (with Cleland).
25. On the anatomy and possible mode of transmission of Filaria (Onchocerca) gibsoni. P.R.S., N.S.W., 44, 1910, 171-189 (with Cleland).
26. Worm nests in cattle due to Filaria gibsoni. Jour. Comp. Path. Therap., **23**, 1910, 335-353. (with Cleland).
27. On Australian avian Entozoa. P.R.S., N.S.W., **44**, 1910, 84-122.
28. Notes on some plant diseases. Agr. Gaz., N.S.W., **20**, 1910, 563-566.
29. Notes on a fungus found destroying potatoes. Agr. Gaz., N.S.W., **20**, 1910, 699-701.
30. Some further notes on Maize smuts. Agr. Gaz., N.S.W., **20**, 1910, 669-670.
31. The Haematozoa of Australian Batrachia, I. P.R.S., N.S.W., **44**, 1910, 252-261 (with Cleland).
32. The Haematozoa of Australian Reptilia, I. P.L.S., N.S.W., **35**, 1910, 677-685 (with Cleland).
33. Note on the occurrence of Pentastomes in Australian cattle. P.R.S., N.S.W., **44**, 1910, 315-318 (with Cleland).
34. The fungous disease of lucerne. In Farmers' Bull., No. 37, Oct. 1910, 102-104.

35. Ecto-parasites collected from rodents. Rep. Govt. Bur. Microbiol., N.S.W., for 1909 (1910), 20-21.
36. List of Entozoa recorded as occurring in man and domesticated animals and birds in Australia. Rep. Govt. Bur. Microbiol., N.S.W., for 1909 (1910), 74-81.
37. Worm nests in cattle and camels. Rep. Govt. Bur. Microbiol., N.S.W., for 1909 (1910), 91-99 (with Cleland).
38. Plant diseases met with during the year. Rep. Govt. Bur. Microbiol., N.S.W., for 1909 (1910), 54-57.
39. Various papers, officially reprinted, in Rep. Govt. Bur. Microbiol., N.S.W., for 1909 (1910):—
    (a) (Articles on Australian parasitic) protozoa, 35-46 (with Cleland).
    (b) Potato diseases, 57-63 (with Tidswell).
    (c) Maize diseases, 70.
    (d) Diseases of banana plants, 71-73 (with Tidswell).
    (e) (Articles on Australian) Cestoda, 82-89.
40. The Haematozoa of Australian birds, I. T.R.S., S.A., 1910, 100-114 (with Cleland).
41. The Haematozoa of Australian fish, I. P.R.S., N.S.W., **44**, 1910, 406-415 (with Cleland).
42. Notes and exhibits. P.L.S., N.S.W., **35**, 1910, 28, 48, 136, 309-310, 522-523, 659-660, 804.
43. Notes and exhibits. P.R.S., N.S.W., **44**, 1910. Abstr. xi-xiv, xvii.
44. Notes on worm nests in Australian cattle and in camels. Bull. Dept. Trade and Customs, Commonw. Govt., 1911, 35-58 (with Cleland).
45. American maize smut. Agr. Gaz., N.S.W., **22**, 1911, 319-320.
46. The Entozoa of Australian Marsupialia and Monotremata, II, P.L.S., N.S.W., **36**, 1911, 47-57.
47. New species of avian cestodes. P.L.S., N.S.W., **36**, 1911, 58-80.
48. Notes on some Mallophagan generic names. P.L.S., N.S.W., **36**, 1911, 321-328 (with Harrison).
49. Echinorhynchus pomatostomi, a subcutaneous parasite of Australian birds. P.R.S., N.S.W., 1911, 111-115 (with Cleland).
50. A case of injury and repair in the cuticle of a nematode. Rep. Aust. Assoc. Adv. Sci., 13, 1911 (1912), 299-300 (with Cleland).
51. The Helminth parasites of man in Australia. Rep. Aust. Assoc. Adv. Sci., **13**, 1911 (1912), 301-314 (with Cleland).
52. The Haematozoa of Australian Reptilia, II. P.L.S., N.S.W., **36**, 1911, 479-491 (with Cleland).
53. The Haematozoa of Australian birds, II. P.R.S., N.S.W., **45**, 1911, 415-443 (with Cleland).
54. Proteocephalus gallardi, a new cestode from the black snake. Ann. Qld. Mus., **10**, 1911, 175-182.
55. On the occurrence of worm nodules in cattle—a summary. P.R.S., Qld., **23**, 1911, 207-231.
56. A census of Australian reptilian Entozoa. P.R.S., Qld., **23**, 1911, 233-249.
57. A brief account of the worm nodules occurring in cattle. Qld. Agr. Jour., Dec. 1911, 309-311.
58. Notes and exhibits. P.L.S., N.S.W., **36**, 1911, 93, 157-158.
59. Exhibits. Aust. Med. Gaz., 1911, 336.
60. A Collection of Mallophaga from the Kermadecs. Trans. N.Z. Inst., **44**, 1911, 363-373 (with Harrison).
61. On a re-examination of Krefft's types of Entozoa, etc. Rec. Aus. Mus., **9**, 1912, 1-36.
62. The relative dimensions of the red blood cells of vertebrates, especially of birds. Emu, 12, 1912, 188-197 (with Cleland).
63. A census of Australian Mallophaga. P.R.S., Qld., 1912, 1-15 (with Harrison).
64. A list of Mallophaga found on introduced and domesticated animals in Australia. P.R.S., Qld., 24, 1912, 17-22 (with Harrison).
65. Notes on some Entozoa. P.R.S., Qld., **24**, 1912, 63-91.
66. Internal parasites recorded from Australian birds. Emu, **12**, 1912, 105-112.
67. New species of cestodes from Australian birds. Mem. Qld. Mus., **1**, 1912, 211-214.
68. Notes on Australian Pediculids. P.R.S., Qld., **24**, 1912, 105-109 (with Harrison).
69. Species of Haemoprotozoa met with during 1910-1911. Rept. Govt. Bur. Microbiol., N.S.W., for 1910 and 1911 (1912), 74-83 (with Cleland).
70. Tabular statements of Haematozoa occurring in wild and domestic animals in Australia. Ibid., 83-88 (with Cleland).
71. Memorandum on Surra. Ibid., **72** (with Cleland).

72. Introductory remarks concerning some modes of dispersal of Helminth parasites (with Tidswell), ibid, 112-113.
73. Official reprint of various papers published elsewhere. Rep. Govt. Bur. Microbiol., N.S.W., for 1910 and 1911 (1912):—
    - (a) The Helminth parasites of man in Australia, 113-119 (with Cleland).
    - (b) A note on the occurrence of Pentastomes in Australian cattle, 119-120 (with Cleland).
    - (c) On Australian avian Entozoa, 122-136.
    - (d) Microfilaria in the blood of Australian birds, 136-137 (with Cleland).
    - (e) On some fungi found in potatoes, with special reference to Armillaria mellea, 177-179.
    - (f) Irish blight in tomatoes, 179-180.
    - (g) American maize smut, 181.
    - (h) On some fungi found on fruit, 182-184.
    - (k) Fungous diseases of lucerne, 184-185.
74. Cestoda and Acanthocephala. Rep. Townsville Tropical Institute, 1911 (1913), 75-96.
75. Second report on the Cestoda and Acanthocephala collected in Queensland. Ann. Trop. Med. Parasit., **8**, 1914, 105-112.
76. Notes and exhibits, Endoparasites (Trematoda). P.R.S., Qld., **26**, 1914, 69.
77. On some new Queensland Endoparasites. P.R.S., Qld., **26**, 1914, 76-84.
78. Report of the Prickly Pear Travelling Commission, Nov. 1912—April 1914. Qld. Parl. Rep. (1914), 1-20 and 131, 66 figs. (with Tryon).
79. Notes on an exhibit of specimens of Ceratodus. P.R.S., Qld., **27**, 1915, 58-59 (with Bancroft).
80. Helminthological notes. Mem. Qld. Mus., **5**, 1916, 186-196.
81. Mallophaga from Marsupialia, I. Parasitology, **8**, 1916, 338-359, 14 text figs. (with Harrison).
82. Presidential Address. P.R.S., Qld., 28, 1916, 1-30.
    Obituary of Frederick Manson Bailey, 3-10.
    Obituary of C. W. Devis, 10-17.
    The eradication of prickly pear, 22-26.
    Worm nests in cattle, 26-30.
83. Census of Endoparasites recorded as occurring in Queensland, arranged under their hosts. P.R.S., Qld., **28**, 1916, 31-79.
84. The Endoparasites of the dingo. P.R.S., Qld., **28**, 1916, 96-100.
85. Ecological notes on the littoral fauna and flora of Caloundra, Qld. Qld. Naturalist, **2**, 1917, 53-63.
86. On a new species of Pedicellina from Sydney Harbour. P.R.S., Qld., **29**, 1917, 60-63 (with Walker).
87. The cattle tick in Australia. Bull. 1 Advisory Council Sci. & Industry, Melbourne, 1917 (with Stewart and others).
88. Worm nodules in cattle. Bull. 2 Advisory Council Sci. & Industry, Melbourne, 1917 (with Dodd and others).
89. Notes on a Saproleugnia epidemic amongst Queensland fish. P.R.S., Qld., **29**, 1917, 125-131.
90. Tick resistance of cattle. Agr. Gaz., N.S.W., **29**, 1918, 319-320 (with Bancroft).
91. Tick resistant cattle. Qld. Agric. Jour., **9**, 1918, 171-172 (with Bancroft).
92. Notes on certain Entozoa of rats and mice, together with a catalogue of the internal parasites recorded as occurring in rodents in Australia. P.R.S., Qld., **30**, 1918, 53-78.
93. The Endoparasites of the domestic pigeon in Queensland. Mem. Qld. Mus., **6**, 1918, 168-174.
94. A tick resistant condition in cattle. P.R.S., Qld., **6**, 1918, 219-317 (with Bancroft).
95. A note on the occurrence of Mullerian ducts in the male of Hyla caerulea. P.R.S., N.S.W., 1918, 461-462 (with Gillies).
96. Notes on records of Tree Kangaroos in Queensland. Aust. Zoologist, **1**, (6), 1918, 153-156 (with Gillies).
97. Myobolus hylae, a parasite of the reproductive organs of the Golden Frog, Hyla aurea. Aust. Zoologist, **1**, (6), 1918, 171-175 (with Bancroft).
98. Notes on miscellaneous Endoparasites. P.R.S., Qld., **30**, 1918, 209-218.
99. Some new Sporozoon parasites of Queensland freshwater fish. P.R.S., N.S.W., 1918, 520-528 (with Bancroft).
100. Report on Mr. Munro Hull's claims re resistant cattle. Qld. Agr. Jour., Jan. 1919, 31-35; also in Science and Industry, 1 (1), 1919, 57-62; also in Rev. Appl. Entomol. B., **7**, 1919, 112-114 (with Bancroft).

101. Pseudobonellia, a new Echinoid genus from the Great Barrier Reef. P.L.S., N.S.W., 44, 1919, 213-230 (with Tiegs).
102. Notes on Australian Chaetognatha. P.R.S., Qld., 31, 1919, 28-41 (with Taylor).
103. The Lingulidae of the Queensland coast. P.R.S., Qld., 31, 1919, 46-82 (with Hirschfeld).
104. Tick resistance in cattle; a reply to criticism. P.R.S., Qld., 31, 1919, 173-180 (with Bancroft).
105. Control of the cattle tick; life history investigated. Science and Industry, 1, 1919, 419-425.
106. The life histories of Musca australis and Musca vetustissima. P.R.S., Qld., 31, 1919, 181-203 (with Bancroft).
107. Notes on the Chaloid parasites of Muscoid flies in Australia. P.R.S., Qld., 32, 1920, 19-30 (with Bancroft).
108. Experiments with certain Diptera as possible transmitters of bovine Onchocerciasis. P.R.S., Qld., 32, 1920, 31-57. (with Bancroft).
109. The life history of Habronema in relation to Musca domestica and native flies in Queensland. J. Roy. Soc., Qld., 32, 1920, 61-88 (with Bancroft).
110. The Chalcid parasites of Muscoid flies in Australia. Science and Industry, Melbourne, 2, 1920, 308-312.
111. The cattle worm-nodule parasite; some experiments with flies as possible transmitters. Science and Industry, 2, 1920, 315-316 (with Bancroft).
112. Flies as transmitters of certain worm parasites of horses. Science and Industry, Melbourne, 2, 1920, 369-372.
113. Notes on the biology of some Queensland flies. Mem. Qld. Mus., 7, 1920, 31-43 (with Bancroft).
114. A new species of Bonellia from Port Jackson. Rec. Aust. Mus., 13, 1920, 73-76 (with Tiegs).
115. Notes on the life history of certain Queensland Tabanid flies. P.R.S., Qld., 32, 1920, 125-131. (with Bancroft).
116. The cattle tick. Science and Industry, Melbourne., 2, 1920, 347-351.
117. Report on the Chaetognatha collected by the Australian Antarctic Expedition. Rep. Aust., Antarctic Exp., 1911-1914, Series C, 6, (2), 1921, 16 pp. (with Taylor).
118. Lectures on some Queensland pests. Brisbane Chamber of Commerce, 1920, 9-20. (Prickly Pear, 9-14, Cattle Tick, 15-20).
119. The sheep maggot fly in Queensland. Qld. Agr. Jour., 15, 1921, 244-248.
120. New and little known Sarcophagid flies from South-eastern Queensland. P.R.S., Qld., 33, 1921, 46-90. (with Tiegs).
121. Biological control of prickly pear. Qld. Agr. Jour., 16 August, 1921, 65-68.
122. On the biology and economic significance of the Chalcid parasites of Australian sheep maggot flies. P.R.S., Qld., 33, 1921, 99-128 (with Tiegs).
123. The nodule parasite and allied worms from Queensland cattle. Qld. Agr. Jour., 16 Sept., 1921, 172-174.
124. The freshwater fish epidemics in Queensland rivers. P.R.S., Qld., 33, 1921, 174-210 (with Bancroft).
125. Onchocerciasis in Queensland cattle. T.R.S., S. Aust., 45, 1921, 231-247.
126. Notes on certain Queensland and bush flies. Trans. Intercol. Med. Congr., 11 (Brisbane), 1920 (1921), 265-272.
127. Sarcophagid flies in the Australian Museum collection. Rec. Aust. Mus., 13, 1922, 175-188 (with Tiegs).
128. What part can Chalcid wasps play in controlling Australian sheep maggot flies? Qld. Agr. Jour., 17, 1922, 128-131 (with Tiegs).
129. New Gyrodactyloid Trematodes from Australian fish, together with a reclassification of the superfamily Gyrodactyloidea. P.L.S., N.S.W., 47, 1922, 83-131 (with Tiegs).
130. Report on investigations regarding prickly pear control by biological means. Qld. Agr. Jour., 17, 1922, 136-140.
131. Notes on the biology of some of the more common Queensland Muscoid flies. P.R.S., Qld., 34, 1922, 77-104 (with Tiegs).
132. Some facts regarding the biology of the house fly. Med. Jour. Aust., Oct. 1922, 494-499.
133. Some facts of importance relating to sheep maggot flies. Qld. Agr. Jour., 18, 1922, 272-275.
134. New and known Australian Sarcophagid flies. P.R.S., Qld., 34, 1922, 56-61 (with Tiegs).

135. A synonymic list of some described Australian Calliphorine flies. P.R.|S., Qld., 34, 1922, 66-69 (with Hardy).
136. Across the Andes. Qld. Geog. Jour., **37**, 1922, 55-67.
137. Some Sarcophagid flies from Lord Howe Island. Rec. Aust. Mus., **14**, (1), 1923, 62-71 (with Hardy).
138. A revision of the Australian Diptera belonging to the genus Sarcophaga. P.L.S., N.S.W., **48**, 1923, 94-129 (with Hardy).
139. Observations regarding the life cycle of certain Australian blowflies. P.L.S., Qld., **35**, 1923, 21-42 (with Hardy).
140. A bacterial disease destructive to fish in Queensland rivers. T.R.S., S. Aust., **47**, 1923, 157-161 (with Hitchcock).
141. A bacteriosis of prickly pears (Opuntia sp.). T.R.S., S. Aust., **47**, 1923, 162-164 (with Hitchcock).
142. A survey of the Australian sheep maggot fly problem. T.R.S., S. Aust., **47**, 1923, 201-211.
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INDIVIDUAL ASPECTS IN THE CULTURE OF THE AUSTRALIAN ABORIGINES

BY H. V. NOONE (COMMUNICATED BY N. B. TINDALE)

Summary

The remarkable variety in form, size and function of the stone implements used by the Australian aborigines, and the employment of several different stone-working techniques in producing them, prompts speculation as to whether it is likely that this well-developed industry is the outcome of the Australian aborigine's own natural inventiveness and dexterity, and if so to what extent this is true.

INDIVIDUAL ASPECTS IN THE CULTURE OF THE AUSTRALIAN ABORIGINES

By H. V. V. Noone

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The remarkable variety in form, size and function of the stone implements used by the Australian aborigines, and the employment of several different stone-working techniques in producing them, prompts speculation as to whether it is likely that this well-developed industry is the outcome of the Australian aborigine's own natural inventiveness and dexterity, and if so to what extent this is true.

Most unfortunately stratigraphic evidence has not yet been established to reveal a chronological sequence of the various implement-types that have been found. Furthermore, the question of whether or not it can be said that the Australian aborigine's occupation of Australia, as to duration and outside interference, was such as to permit independent evolution, has not yet been satisfactorily answered. That he enjoyed a prolonged period of isolation and freedom from contact of any consequence with more highly evolved physical stocks is believed to be evidenced by the primitive physical characteristics he still exhibits amongst the tribes found in all areas except the extreme north. D. J. Mahony (4) claimed on the basis of the geological evidence of a skull found at Keilor, near Melbourne, that Australoid-Tasmanoid types of men were living in Australia some 140,000 years ago, which early date, however, has not yet received general acceptance. After careful study of the question of influence on North-western Australia from the East Indies, Dr. D. S. Davidson (2, p. 78) says "at least we have no evidence to indicate any perceptible foreign influence on the Australian race or culture prior to the latter half of the 18th century." Melanesian contacts, via Cape York and adjacent territory, sufficient to have any notable result, seem to be of comparatively recent date and also of limited effect.

Going on to an examination of the many stone implements used in Australia, one finds (compare 5, 7 and 8) that they range from crude, archaic-type specimens of an almost "eolithic" aspect, through what may be considered transitional stages, to more specialized and developed examples of excellent workmanship, in fact such a series as one might expect to find in a more-or-less self-contained industry. Tools occur in this Australian aboriginal ensemble which are merely suitably-shaped blocks used along their natural edges, with perhaps some rudimentary trimming, together with roughly-flaked core implements, such as the "horse-hoof," "karta," and pebble choppers. As a possible result of improved craftsmanship, flaked bifacial tools are found of elliptical and cordiform shapes. A further step may be the presence of flake tools culminating in the semi-discoidal "tula" adze-flake, and a somewhat larger form known as the "arapia". Related to this advance in technique, which required the preparation of the nucleus, may be certain blade tools, such as the women's knife and the excellent long quartzite knives and points used by the men. Improvements in secondary working by the employment of trimming by pressure produced the South Australian uniface spearhead, called the "pirri," which was apparently developed into a bifacial form, examples of which have been manufactured during recent times of bottle glass.

A microlithic industry, comprising most of the established geometric forms, but lacking the micro-burin, completes the Australian aboriginal's range in rough outline. A standardized burin outfit is absent, but most of the other tools and weapons of European Stone Age man from Palaeolithic and Mesolithic horizons are represented, as recently pointed out by the writer (9), and with these the Australian aboriginal examples compare favourably. Thus there would seem to be a fair indication that we have in Australia a people who have employed the various stone-working techniques to produce the many forms of implements used in Europe during a period of roughly half a million years duration. Unless we assume (in spite of the lack of archaeological evidence of the necessary intervening routes of diffusion) that the Australian aborigine acquired his methods of manufacture and stone implement types from each one of the European Stone Age cultures, by not one only, but by repeated culture contacts extending over many thousands of years, the probability must be admitted that much of his stonecraft has been independently developed. It may well be that being free to follow his own bent in the practice of the crude stone-working technique, with which he was apparently endowed when he entered Australia, he instituted by his natural genius new methods of manufacture and improved forms of implements to meet his changing requirements, and in this manner carrying out the usual evolution of the stone industry: core and flake ⟶ blade ⟶ microlith.

Until recently edge-ground stone axes were in use over part of the eastern area of the Australian continent, but this technique, together with the method of shaping by pecking, appears to be of a recent and limited foreign introduction.

Turning to other items of the Australian aborigine's material culture, as well as his social organization, certain traits, just as in the case of the stone implements, will be found which reveal the presence of simple, possibly proto-type, forms together with transitional varieties alongside the more complex or developed aspects of the culture. For instance, the several types of spear-thrower, spear-shafts, spear-heads, the simple throwing-sticks, as well as the various boomerang forms, different burial customs, initiation ceremonies, body decoration, the various classificatory and marriage systems, and the conception beliefs.

From another point of view there are certain items of Australian aboriginal culture which appear to be exclusive to it, as they are unknown as standard forms in the rest of the world, such as the flake-pick and hatchet (kodj), and the flake-adze *cum* spear-thrower, and stone tjuringas. In addition, there are features which are not found among any of the tribes inhabiting either the adjacent islands or the mainland. These include (a) a developed geometric microlith industry, (b) a knapping technique that produced superb blades, (c) pressure-trimmed spear-heads, (d) mastic gum hafting, (e) stone barbed spear-heads, (f) composite chipped saw-knives (taap), (g) rock-engravings, and (h) subincision. These all imply the definite cultural independence of the Australian aboriginal. Furthermore, as Porteus (10, pp. 245-246) has stated, certain aspects of Australian aboriginal culture show a unity of pattern and form only appropriate to an inhospitable environment, such as exists on the Australian continent. They seem quite unsuitable to the living conditions of people occupying islands of tropical luxuriance and extended seaboards, and hence are unlikely to have originated among them. These traits include (a) the boomerang and the (b) spear-thrower *cum* flake-adze (suited only for open country), (c) infanticide, (d) totemic food taboos, (e) advanced tracking technique, (f) severe initiatory rites, (g) certain marriage regulations (such as infant betrothal), and

(h) absence of hereditary chieftainship. All these are peculiarly adapted to the harsh living conditions, which have no counterpart on the islands immediately adjacent to his homeland.

The absence from Australian aboriginal culture of garden cultivation and domestication of animals (except the dingo), the lack of pottery, and non-use of the bow and arrow, which are all so characteristic of the cultures of adjacent areas, including New Caledonia, may well be due to environmental unsuitability, or on the other hand, to prolonged cultural isolation, which the writer believes is much more probable.

This contention that much of his material culture is probably due to the Australian aboriginal's own independent development receives some support from an analysis of Tasmanian culture traits. A comparison of these with those found in Australia has shown many similarities. Dr. D. S. Davidson (1) has stated in his paper on "The Relationship of Tasmanian and Australian Cultures" that "Tasmanian and Australian cultures not only are characterised by a general similarity of pattern but fairly comparable traits are most like old Australian traits," and also "secondly cognizance should be taken of the fact that there are no Tasmanian traits of any importance which do not also appear in Australia with one major exception, which has puzzled so many writers—Tasmanian stone work."

Shortly before the publication of Dr. Davidson's paper, Mr. N. B. Tindale (11) had identified among a series of Tasmanian implements some examples of the "horse-hoof," "karta," and pebble-choppers typical of the non-flake stone industry of Kangaroo Island (South Australia), and he further points out that the dingo is absent from both islands. Now this pebble industry has been shown by Prof. H. L. Movius, Jr. (6) to date ultimately from Middle Pleistocene times on the basis of evidence from various localities in South-eastern Asia. Its occurence in Australia and Tasmania implies not only a considerable antiquity for the original immigrant Tasmanians, but also a northern origin.

In 1943 Dr. T. D. Campbell and the writer (3) reported on the finding of old camp-sites south-east of Adelaide, South Australia, which yielded quantities of nosed scrapers (the most typical of Tasmanian implements), as well as concave and squat end-scrapers of the same type as those produced by the Tasmanians. In addition, the majority of these tools were manufactured by a technique similar to that found in Tasmania. The major exception quoted by Dr. Davidson, therefore, no longer holds good, for we now know that the stone-making industries of Australia and Tasmania have a close analogy to a certain extent, and furthermore that the apparent relationship does not extend beyond a comparatively early developmental stage. It is precisely this arrested development, or "lagging-behind" feature, which Dr. Davidson found to be true in the case of his comparison of other culture traits. Whereas the Australian aborigine further developed his lithic art until he could produce fine blades and spear-heads trimmed by advanced pressure-flaking technique, as well as delicate geometric microliths and abrupt trimmed points, together with a wide variety of stone implement types, the Tasmanians seem to have stagnated and not progressed beyond a mediocre flake implement stage and a few standardized types. It may be said that the Tasmanians used one or two forms of implements which resemble those of the Mousterian and Aurignacian cultures, but the Australian aborigine evolved types like some in use during the Périgordian, Solutrean and Mesolithic times in Europe (compare Noone, 9). At most the Tasmanians achieved what is little more than an elementary tool outfit mainly comprising core, carinate and concave scrapers, a few chopping-tools,

some squat end-scrapers and borers, but their main standby—in fact their dominant implement—was the nosed scraper.

In view of the above it seems highly probable that at some time in the distant past, before contact with Tasmania was broken off, the Australian aborigine had reached a stage of development in stone working which is represented, more or less, by what we now regard as "Tasmanian". If that is so, then all the further advances which we find that the Australian aborigine has made in his lithic art beyond that stage are either due to subsequent contacts with higher cultures, or to his own independent efforts. It has been shown above that several important items found in the Australian stone-working industry are either exclusive or not found, as far as is now known, among the peoples of the nearby islands. To this extent an independent development seems to be definitely indicated.

Generalizing, the view may be advanced that there are fair grounds for considering that whatever and whenever his early origin, the Australian aborigine, as a result of his geographical isolation, and largely by his own efforts, has differentiated himself from the outside world by successfully accommodating his life to his own particularly harsh environment, and in so doing has evolved a varied and efficient culture which includes many traits (especially marked when the techniques employed in the manufacture of stone tools is considered) that show parallel development with other primitive Stone Age cultures of the world. Alternatively (and this does not seem at all likely) we are faced with the explanation that Australia is an unique emporium and custodian of various primitive arts and customs acquired, down through many ages, from all quarters of the globe.

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LAKE EYRE IN FLOOD, 1950 – MUDS, SALTS, ETC

BY CHARLES FENNER

Summary

Lake Eyre lies in a great tectonic (probably Plesitocene) sag or downwarp in northern South Australia. It has a vast catchment area of about 400,000 square miles, mostly arid to semi-arid. Now and then, in the history of white occupation, there have been shallow pools of water brought down by the endoreic streams from Queensland, South Australia, and Northern Territory. The shore line is about 40 feet below sea level, and the depth of the lake, when full, appears to be something about 20 feet, making the bottom approximately 60 feet below sea level. But, with an evaporation of nearly ten feet per year, these pools soon dry up, and for the most part "Lake" Eyre has been no more than a vast playa or salt-pan, nearly 4, 000 square miles in extent.

LAKE EYRE IN FLOOD, 1950 — MUDS, SALTS, ETC

By Charles Fenner*

[Read 12 April 1951]

Lake Eyre lies in a great tectonic (probably Pleistocene) sag or downwarp in northern South Australia. It has a vast catchment area of about 400,000 square miles, mostly arid to semi-arid. Now and then, in the history of white occupation, there have been shallow pools of water brought down by the endoreic streams from Queensland, South Australia, and Northern Territory. The shore line is about 40 feet below sea level, and the depth of the lake, when full, appears to be something about 20 feet, making the bottom approximately 60 feet below sea level. But, with an evaporation of nearly ten feet per year, these pools soon dry up, and for the most part "Lake" Eyre has been no more than a vast playa or salt-pan, nearly 4,000 square miles in extent.

It naturally attracted little interest. But in 1949 and in the early winter of 1950, as well as in later months of the same year, exceptional floods occurred in the Cooper, Diamentina, Finke, Warburton, Macumba, Frome, and other contributing streams, and the Lake became full of water for the first time in recorded history, (over 100 years). This aroused the interest of various enthusiastic young men, mostly of the Brooks and Bonython families. The area was visited by car, flown over by aeroplane, and boats were launched for exploratory purposes.

In 1923 G. H. Halligan, of Sydney, flew over Lake Eyre, and noted well-defined deltas at the mouths of the principal streams, tree-like deltas as pictured by Holmes (Walkabout, November 1950), A few months later Halligan made an effort to effect a boat landing at the mouth of the Frome River, but found the lake "dry as far as he could see." In 1929, Dr. C. T. Madigan flew over the "Lake," but could detect no water, and put forward his belief that the lake would never fill again.

Howchin mentions that despite its enormous evaporation each year of almost 120 inches, Lake Eyre is not excessively salt as compared with other internal basins such as the Great Salt Lake and the Dead Sea, but its exact salinity was not then known. This fact, taken with the recent period of fertility (plant and animal life of the later Diprotodon Age, Pleistocene to Recent) suggests that Lake Eyre has been formed within comparatively late geological times.

Warren Bonython and party have also visited the lake several times to make records of evaporation, salinity, etc.

The purpose of this note is to describe four interesting specimens handed to Mr. H. M. Hale (Director South Australian Museum) by Mr. H. G. Brooks in July, 1950, as well as my own impressions of a flight over the lake in October, 1950.

No. 1 was a sample of water from 15 miles inside the lake. It was clear, with a small amount of clay that settled as sediment. It is fresh to the taste and is apparently characteristic Cooper Creek flood water. From the air the salt-water parts of the lake appear as a beautiful green-blue colour; the fresh-water portions are brown with mud. The whole outlook upon this rare inland sea was beautiful and impressive.

* South Australian Museum.

No. 2 specimen was of some shore sands. These have been examined under the lens and tested with acid, etc.; they are wholly of translucent quartz, with an occasional fragment of black material, possibly ironstone. (Plate i, fig. 2). All the grains were of fairly even size and equally waterworn flattish and irregular in outline. The largest pieces are about 3 mm. in their longest diameter, and the smallest range down to 1 mm. They closely resemble in shape the material of a shingle beach, except that their size is so small and their composition so regular. They suggest a fairly long historic period of shore-line erosion.

No. 3 is the most interesting of the specimens, consisting of a handful of wet plastic mud from the bottom of the lake, which had stuck to the oars of the boats used. When handed to the writer by Mr. Hale it had the consistency of plasticene, but black and sticky. It was placed on a table in the Museum. In a few weeks it had dried, and had developed an extraordinary covering of long, transparent, twining hair-like crystals. These were photographed on 15/8/50.

In order to obtain a better and unbroken specimen, the mud and crystals were wetted and worked up to their original muddy appearance; this mud was placed in a ring-like form in a glass dish on 17/8/50. In five days the first signs appeared of short upright crystals growing from the crystalline content that had been sealed up in the mud. In three weeks a rich crop of shining transparent crystals had again appeared. These did not resemble any known mineral, least of all the cubic crystals of sodium chloride, which mineral was, of course, the one most to be expected.

Dr. S. W. Pennycuick, of the University of Adelaide, kindly analyzed a specimen, and proved it to consist of over 90% common salt, with a small amount of sulphates.

Because of the extraordinary hair-like and twining habit of the crystals, it was considered worth while having a second photograph taken and recorded, which was done on 20/10/50, after about eight weeks drying. During the period of growth the specimen was covered by a glass basin, and was not subjected to any air movement whatever, (Plate i, fig. 1). Current mineralogical text books describe salt ($NaCl$) as occurring in various forms: cubic, granular, massive, columnar, etc., but not as twisting hair-like crystals.

Prof. Sir Edgeworth David had suggested that in the Pleistocene Ice Age, when Tasmania and the Kosciusko areas were glaciated, "Lake Eyre was probably about ten times as large as it is at present, and over 200 feet deep, extending to beyond Lake Frome in the south-east and nearly to Cordillo Downs on the north-east." (Explanatory notes to a new geological map of Australia: David, 1932).

During what may become an historic flood period, in October, 1950, when north Lake Eyre was brimming full, and the Cooper, Diamentina, Alberga, Mucumba, Finka, and other endoreic rivers were flooded, the writer was in a plane which flew at a low level over the lake and river mouths, thence eastward till the eastern shores of Lake Frome were visible. A careful lookout was kept for possible lake terraces or structures of the ancient larger Lake Eyre ("Lake Dieri"), but apart from some suggestive "cliffs" nothing definite was to be seen. A land search for these ancient terraces is desirable.

It is clear that there is great scientific interest in Lake Eyre, and it is hoped that further information will steadily be collected, as is at present being done by Messrs. H. G. Brooks, Elliott Price, Eric Bonython, and others already mentioned. Lake Callabonna is adjacent to the Lake Eyre system, and here, many years ago were found the remains of the giant marsupial

(*Diprotodon*), the giant flightless birds (*Genyornis*), turtles, crocodiles, lung-fish, kangaroos, molluscs and other animals and plants that must but recently have become extinct. It is hoped that further excursions, surface excavations, and collections may soon be made from this mysterious and fascinating region. It was to the generosity of the late Sir Thomas Elder and the scientific skill and persistence of Sir Edward Stirling and Mr. A. Zietz that we owe the wonderful discoveries of over 50 years ago.

Before the period of post-glacial desiccation set in, forests with figs and tree-ferns flourished at Fossil Creek, near Oodnadatta, and this was probably the case elsewhere in that great depression. More remains of the giant flightless bird, *Genyornis newtoni*, are much needed, for the specimens obtained have been few and much broken. They were collected over 50 years ago. It is true also that we need more knowledge of the *Diprotodon australis*, so that we may be better able to picture the animal as it lived and moved; at least four scientific efforts to reconstruct this animal have been made, and each is very unlike the other; of all of them the reconstruction pictured by C. H. Angas seems to be the most unlikely for an animal which, in a relatively brief period, extended its domain over all Australia.

The salinity of the waters (sample 4) is also of interest. Mr. H. Brooks brought in some salty water from far out in the lake, this was handed to me on 26/10/50. A sample was sent to the Department of Mines for analysis, and this was done by Mr. T. W. Dalwood. I have compared it with the salinity of the oceans.

The salinity of the oceans is remarkably constant, though there are minor differences in the oceans and larger seas. The salinity is about 3·3% to 3·7%. This diminishes towards the Poles; also it diminishes to a depth of 800-1,000 fathoms, and thence increases towards the bottom of the ocean beds; 2,311 to 2,616 grains per gallon.

The salts of Lake Eyre, as determined by Mr. Dalwood are:

	Grains per gallon
Sodium chloride	2647·8
Calcium sulphate	85·43
Magnesium sulphate	28·86
Magnesium chloride	19·34
Calcium carbonate	6·67
	2788·10

Stated in another way, the figures are:

	Grains per gallon
Chlorine	1620·5
Sodium	1041·7
SO_4 radicle	83·31
Calcium	27·82
Magnesium	10·77
CO_3 radicle	4·00
	2788·10

This gives us a salinity for Lake Eyre of 3·983% when in full flood, which occurs at most once in 100 years. As the waters evaporate this will, of course, rise towards 100% salinity. The salinity of the muds is extraordinarily high, as shown in earlier paragraphs, but these muds have not been analysed.

Thus the salinity of the Lake Eyre samples, when in full flood, is definitely greater than that of the oceans. This appears to be a matter of extreme interest, and worthy of placing on record along with the account of the muds, sands, etc. From the air the tree-like shapes of the deltaic muds are noticeable, as recorded by Halligan. It may be a century before further observations can be made of Lake Eyre in flood, so that these notes appear worthy of record in scientific literature.

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Fig. 1
The mass of hair-like salt crystals that developed from a sample of Lake Eyre mud.

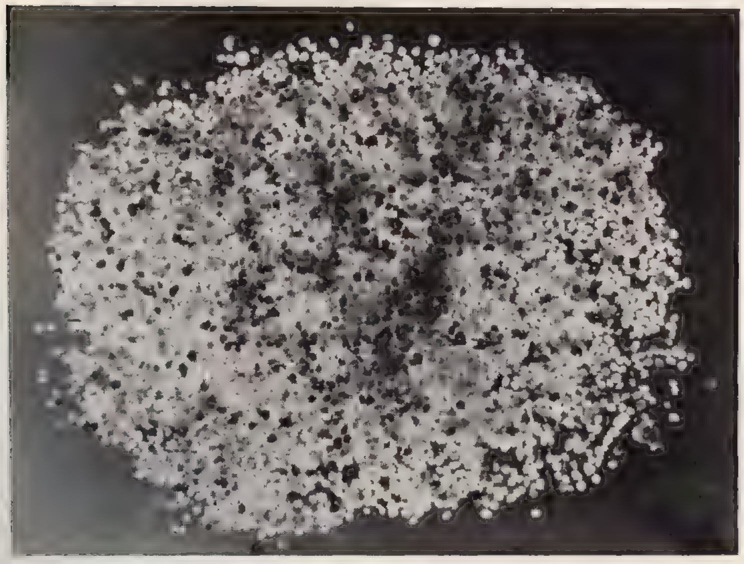

Fig. 2
The small shingle-like abraded quartz crystals found along the shores of the lake.

THE DACETINE ANT GENUS MESOSTRUMA BROWN

BY WILLIAM L. BROWN, JR. (COMMUNICATED BY G. F. GROSS)

Summary

The author described the characteristics of the genus Mesostruma and of M. laevigata n. sp. (from the Victorian Mallee), and M. turneri (from the vicinity of Mackay, Queensland). The validity of the species M. monstrosa Viehmeyer is also discussed.

THE DACETINE ANT GENUS MESOSTRUMA BROWN

By WILLIAM L. BROWN, JR.*

(Communicated by G. F. Gross)

[Read 12 April 1951]

Text Fig. 1, a-c

SUMMARY

The author describes the characteristics of the genus *Mesostruma* and of *M. laevigata* n. sp (from the Victorian Mallee), and *M. turneri* (from the vicinity of Mackay, Queensland). The validity of the species *M. monstrosa* Viehmeyer is also discussed.

Mesostruma was erected in my preliminary revision (1948) to include *Epopostruma turneri* Forel and an undescribed species sent by Mr. John Clark. It is the purpose of the present paper to describe the essential features of *Mesostruma* and of both included species.

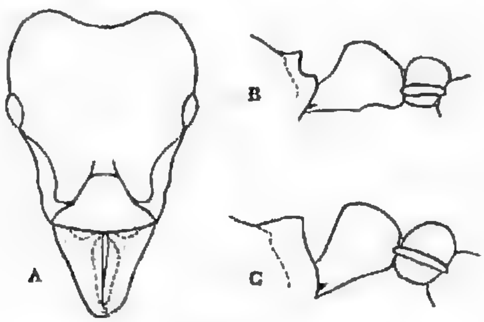

Fig. 1

a. *Mesostruma laevigata* n. sp., small worker paratype, head, dorsal view. b. same, lateral view of propodeal lamella and pedicel. c. *M. turneri* Forel, worker cotype, lateral view of propodeal lamella and pedicel.

MESOSTRUMA Brown 1948

Mesostruma Brown 1948 Trans. Amer. Ent. Soc., 74, 118-119.

Epopostruma Forel 1895 Ann. Soc. Ent. Belg., 39, 424, as sub-genus of *Strumigenys*, part. Emery 1897 Term. Füzetek, 20, 573, part; *idem* 1922 Gen. Ins., Fasc. 174, 330, part.

Worker and female—With the general characteristics of the *Epopostruma* complex, *i.e.*, with large, dorsolaterally placed compound eyes; broad tongue-shaped labrum covering entirely the lesser mouthparts and buccal aperture; palpal segmentation, maxillary five, labial three. Antennal funiculus with five segments, proportioned as in *Epopostruma*.

In generic characters intermediate between *Epopostruma* and *Alistruma* Brown, especially the following: head shape, mandibular form, appendages of petiole and postpetiole. Head with posterior excision less deep and lateral occipital lobes less broadly expanded than in *Epopostruma*, but in both respects less highly modified than in *Alistruma*. Mandibles not so elongate as in *Epopostruma*, with feebly concave external borders, the space between the shafts proper and the middle (line of closure) filled in entirely with a semi-transparent

* Harvard University.

lamina, this lamina with straight, cultrate mesial (apical) margin and straight horizontal basal margin, these two margins meeting at the apex of the oblique, spiniform basal tooth. The basal tooth is similar to that of *Epopostruma* in form and position, but is entirely enclosed in the aforementioned lamina, through which it is clearly visible. The dentition of the apical border restricted to the stout acute apical tooth and a smaller subapical tooth dorsal to the apical and apparently representing the reduced dorsal tooth of the apical fork as seen in *Epopostruma*. Alitrunk much as in *Alistruma*, with or without subdentiform humeri; propodeal lamellae well developed, upper part without well defined internal tooth. Petiole with weakly defined peduncle, well developed node, and without lateral teeth or processes of any kind. Postpetiole transverse, with broad, flat, winglike lateral lamellate expansions resembling those of *Microdaceton* Santschi from the Ethiopian region.

Sculpture much like that of *Epopostruma*, the dorsum of the head and often other parts of the body with spaced circular foveolae or fossettes, each tuberculate and bearing a much reduced, scarcely detectable hair. These foveolae are smaller and more numerous than in *Epopostruma*. Pilosity appressed or subappressed, resembling a very dilute pubescence. Colour varying shades and combinations of ferrugineous, but much darker colouration, may easily exist in members of this genus as yet unknown.

Male unknown.

Genotype: Strumigenys (Epopostruma) turneri Forel, designated by Brown, 1948.

Mesostruma turneri and *M. laevigata* spp. nov. are quite distinct from each other, but preserve the essential generic characters in unequivocal form. The genus is of great interest in its clearcut intermediate phylogentic position, connecting *Epopostruma*, with strumigeniform head and mandibles, to *Alistruma*, which has the head and mandible form, as well as other striking characters of a convergent nature, similar to those of *Smithistruma*. It now seems clear that *Epopostruma*, *Hexadaceton* Brown and the Ethiopian *Microdaceton* are the primitive members of the *Epopostruma complex*, since the general head form and gnathal apparatus which I call "strumigeniform" occurs in all four recent dacetine lines (subtribes) or complexes; it is the only one known in the *Orectognathus* complex (Arestognathiti[1]) and the *Daceton* complex (Dacetiti), of which the latter group is to be regarded as the most primitive surviving dacetine line on the basis of obvious characters.

Among the Epopostrumiti, the genus *Alistruma* occupies a central position in the derived half of the subtribe having triangular mandibles with serially denticulate apical margins and aliform expansions of both petiole and postpetiole. *Colobostruma* Wheeler and *Clarkistruma* Brown are aberrant derivatives of *Alistruma*, as is evident from their structure. *Mesostruma* therefore appears to link the "higher" and "lower" halves of the subtribe. Disregarding the extra-Australasian *Microdaceton*, we see a truly remarkable series of "step genera" among the living epopostrumites. All of these steps are existing today in Australia and New Guinea (the latter region supports one species of *Alistruma* as

[1] The four recent and one fossil complexes within the tribe Dacetini may be treated as subtribes. I prefer to use the suffix "-iti" rather than "-ina" because the latter is too much like a great many (nominative singular) generic name endings. The suffix here used is extremely rare as a termination for generic names, and has the further advantage of differing from the vernacular expressions used for taxonomic groups in all common languages employed in the modern literature. The subtribal names in the Dacetini, with their type genera in parentheses, are as follows: *Dacetiti (Daceton)*; *Orectognathiti (Orectognathus)*; *Epopostrumiti (Epopostruma)*; *Strumigeniti (Strumgenys)*; *Hypopomyrmiciti (Hypopomyrmex)*. All of these subtribal names are here proposed for the first time.

so far known), and there is no reason to accept them as other than the actual surviving stages in the evolution of the group. This evolution is all the more remarkable when one considers its trend. The most derivative of the genera, *Clarkistruma*, is remarkably convergent in structure, habits and habitat to *Smithistruma* Brown, a genus derived from *Strumigenys*-like ancestors which is particularly well developed in the warmer parts of the North Temperate Zone. *Smithistruma* is absent from Australia so far as is known; it has reached certain mountainous regions of western New Guinea, but has not yet been found on the eastern half of that island, in spite of some very thorough dacetine collecting by Biró and others. One is tempted to draw the conclusion that the elongation of the head, shortening of the mandibles, and development of the extraordinary aliform structures of the pedicel, which are in many respects similar to the spongiform appendages so well developed in *Smithistruma* of cooler regions, are all modifications which have developed in response to the stimulation of an unfilled ecological niche. That the short-mandibulate forms are best developed and most numerous in species and individuals in the cooler parts of Australia and Tasmania certainly is a fact, and one strengthening the belief that these species were developed to meet the challenge of the same sort of opportunity which led to the evolution of *Smithistruma*.

Several stocks of the apparently more efficiently competing Strumigeniti have reached Australia from the direction of New Guinea, but it is evident that these migrants have come into the continent relatively recently, for they have failed in all cases to produce forms sufficiently different to merit recognition of even separate species-groups from those known in the Indo-Papuan region, and the total number of species is few. *Strumigenys perplexa* (Fred. Smith) is the only strumigenite known to have reached Victoria and Tasmania, and this species is an efficient tramp through commerce. Had *Strumigenys* arrived earlier in Australia, the evolution of the epopostrumites would probably have taken a very different course. As it is, the Epopostrumiti present one of the most perfect living evolutionary series imaginable, with *Hexadaceton* near the base and *Clarkistruma* at the apex. The latter genus has strongly fused second, third and fourth funicular segments, a condition also found in some strumigenite genera, particularly the probably recently evolved *Miccostruma* of the Ethiopian region.

Mesostruma, to return to the original subject of this paper, is a rare and little-known group. Both *laevigata* and *turneri* are known only from the type collections, and neither collection was accompanied by ecological data. *Laevigata* certainly, and *turneri* probably, were taken in rather dry, warm areas, where probably they were found under stones or logs. Since both *Epopostruma* and *Alistruma* are predatory upon Collembola (Brown, unpublished notes), it seems probable that *Mesostruma* also follows this very deep-seated dacetine mode of living.

MESOSTRUMA TURNERI (Forel)

(Text fig. 1, c)

Strumigenys (Epopostruma) turneri Forel, 1895, Ann. Soc. Ent. Belg., 39, 424, worker.

Epopostruma turneri Emery 1922, Gen. Ins., Fasc. 174, 330.

Mesostruma turneri Brown, 1948, Trans. Amer. Ent. Soc., 74, 119.

Worker—A cotype sent by Mr. Clark measured 3·0 mm. in synthetic aggregate length (TL–).[2] Head length (HL) 0·76 mm.; mandibular extension (ML)

[2] Measurements and indices used here are essentially as in my other papers on the dacetine ants. For explanations, see Mushi, xx, 2 (1949). A much more thorough explanation will appear in a forthcoming article soon to be published in the American Midland Naturalist.

0·34 mm.; maximum measurable length of alitrunk (WL) 0·84 mm.; cephalic index (CI) 100; mandibulo-cephalic index (MI) 45. A second cotype sent by Mr. H. Donisthorpe from the British Museum had an HL of 0·80 mm.; MI 43, CI 98. Two or three other cotypes seen in Australian museums were close to these in size and proportions, but were not actually measured. Sufficient material is not available for me to say much about the degree of polymorphism in the worker caste of this species.

Distinguished by the broad, convex head, with very convex, protruding eyes. Humeri broadly and evenly rounded, without traces of angulation or dentation. Propodeal lamellae and petiole as in fig. 1 c. Body in general rather opaquely sculptured, with spaces between foveolae mostly minutely reticulate, coriaceous or subgranulose; segment I of gaster with dorsum finely striate longitudinally and subopaque for more than the basal half of its length. Head ferrugineous in colour, darker than the rest of the body, which is ferrugineous yellow, gastric segment I dorsally lighter yellow.

Female and male unknown to me.

Type locality—Mackay, Queensland (Gilbert Turner, May 1894). Cotypes in the Forel Collection, British Museum (Natural History), J. Clark collection, and in several of the larger Australian museums. The locality near Mackay, where Turner probably collected this ant, is now apparently under cultivation. Originally, it was more than likely dry, low woodland like that covering most of the coastal strip of Queensland.

Mesostruma laevigata, n. sp.

(Text fig. 1, a, b)

Worker—Holotype and 14 paratypes. Weakly polymorphic. TL 2·9 to 4·2 mm.; HL 0·66 to 0·89 mm.; WL 0·72 to 1·12 mm.; CI 85 (smaller individuals) to 93 (larger individuals); MI 37 to 44 (70% of individuals 39 to 41, mean 40, no correlation between MI and HL or CI). Present series, from a single nest, too small and so not suitable for statistical analysis, but shows slight tendency toward division into large, broad-headed and small, narrow-headed castes.

Head shape as in fig. 1a; narrower than in *turneri*, with larger but only weakly convex eyes. Humeral angles acutely subdentate. Propodeal lamellae as in figure, the upper and lower angles varying slightly in prominence; translucent, without distinct trace of solid tooth in upper angle. Petiole narrower and relatively less massive than that of *turneri;* posterior descending face of node weakly or not at all convex seen in profile.

Body over-all much more smooth and shining than in *turneri*, with the spaces between the foveolae, especially on the thorax, petiole and postpetiole wider and smooth and polished for the most part. Gastric dorsum smooth and shining, with a few minute, indistinct vestiges of longitudinal costulae or striae in the articular groove between postpetiole and gaster. Colour medium ferrugineous yellow, gaster lighter, clear honey-yellow.

Female—Gynetype and one paragynetype. TL 4·7, 5·4 mm.; HL 0·92, 0·93 mm.; WL 1·36, 1;40 mm.; CI 91, 93; MI 37, 39. Dealate. Differing only in the usual features of full sexuality from the workers.

Type locality—Sea Lake, Victoria (J. C. Goudie). Sea Lake is in north-western Victoria, in the dry Mallee District. Dominant vegetation in this region is the shrubby mallee (*Eucalyptus dumosa* and related forms), but I have no information as to the precise type of nest site.

The holotype and gynetype, pith paratypes, returned to Mr. John Clark, for eventual placement in the Commonwealth Scientific and Industrial Research

Organization collection at Canberra; paratypes also in the collections of the Museum of Comparative Zoology, Harvard University, the U.S. National Museum, the South Australian Museum, and elsewhere.

? Mesostruma monstrosa

Mesostruma monstrosa Viehmeyer *incertae sedis Epopostruma monstrosa* Viehmeyer, 1925, Ent. Mitt., 14, 30-31, female?

? *Mesostruma monstrosa* Brown, 1948, Trans. Amer. Ent. Soc., 74, 119. gynandromorph?

This species was described from a specimen showing right-left asymmetry of the mandibles; from the somewhat vague details given, one would assume it to be a gynandromorph. Viehmeyer compared it with *turneri* and with *Epopostruma quadrispinosa* Forel. Adapted extracts from the original description:

"Length 4·5 mm. Reddish-brown, gaster dark brown. Mandibles basically as in *turneri*, with the same basal tooth. Right shorter, a bit broader than the left, and with a more convex (mehr gebogen) outer border. The left with two quite similar acute teeth at least three times as long as broad. The right has only the under one similarly formed; the upper one is only a short, truncate piece (as in *Odontomachus*) in appearance."

"Head longer and more slender than in *turneri*, more deeply excised behind."

Viehmeyer mentioned that the closest form is *E. quadrispinosa*, and the description of the left mandible, especially the (apical?) teeth, seems to bear this out. However, the description as a whole is confused and vague and seems to show that the author had no clear idea of either of the two species against which comparison was made. This form can only be considered hopelessly uncertainly placed until it is critically re-examined by a competent worker. The locality given is Trial Bay, but Mr. Clark (in litt.) questions the accuracy of this and other Australian locality citations of Viehmeyer. After having dealt with this and other examples of Viehmeyer's systematic publication, I am inclined to the opinion that not only the genus and type locality are to be questioned, but perhaps even the tribal placement in the Dacetini. It is unfortunate that this apparently abnormal specimen was ever formally named.

Key for the separation of the two adequately known *Mesostruma* species, based on the workers.

Humeri acutely subdentate; gaster largely smooth and shining (Victorian Mallee) .... *laevigata* n. sp.

Humeri gently rounded; gaster finely longitudinally striate over the basal half or more of the dorsum of segment I (vicinity of Mackay, Queensland) .... *turneri* (Forel)

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TWO UNDESCRIBED AUSTRALIAN GASTEROMYCETES

BY G. H. CUNNINGHAM (COMMUNICATED BY J. B. CLELAND)

Summary

Hymenogaster effodiendus n. sp. Peridium pyriforme, basi brevibus radicibus ad. Substratum adjunctum, nodoso-areolatum, viriditate flavum, siccitate brunneo-rubrum, a 600 µ crassum, duobus stratis, interiore parte pseudoparenchymatosa, 30-70 µ crassa, brunnea, exteriore hyphis in radiis laxo ordinatis et in matrice crassa et glutinosa sitis. Gleba pallide ferruginea, cellulis ellipticis, ad 0.5 mm. longis, a latere compressis, vacuis, lamellis tramae 90-150 µ crassis, hyphis hyalinis intextis, basidiis 2-4 sporis. Sporae globosae aliquot subglobosae, 9-12 µ diam, endospora fusca, 1 µ crassa, epispora fusca, glutinosa, 1.5 µ crassa, fortiter areolata et opaca, tecta.

TWO UNDESCRIBED AUSTRALIAN GASTEROMYCETES

G. H. Cunningham*

(Communicated by J. B. Cleland)

[Read 10 May 1951]

Hymenogaster effodiendus n. sp.

*Peridium pyriforme, basi brevibus radicibus ad substratum adjunctum, nodoso-areolatum, viriditate flavum, siccitate brunneo-rubrum, a 600 μ crassum, duobus stratis, interiore parte pseudoparenchymatosa, 30-70 μ crassa, brunnea, exteriore hyphis in radiis laxo ordinatis et in matrice crassa et glutinosa sitis. Gleba pallide ferruginea, cellulis ellipticis, ad 0·5 mm. longis, a latere compressis, vacuis, lamellis tramae 90-150 μ crassis, hyphis hyalinis intextis, basidiis 2-4 sporis. Sporae globosae aliquot subglobosae, 9-12 μ diam., endospora fusca, 1 μ crassa, epispora fusca, glutinosa, 1·5 μ crassa, fortiter areolata et opaca, tecta.

Plants pyriform, 5-7 mm. tall, 4-5 mm. diameter, attached by a short rooting base 1-2 mm. long. Peridium nodose-areolate, when fresh bright yellow, drying reddish-brown, to 600 μ thick, probably viscid when fresh; of two layers, an inner narrow zone of pseudoparenchyma, 30-70 μ thick, with hyphal cells coloured brown, the outer of loose hyphae radially arranged and embedded in a thick gelatinous matrix. Gleba pallid ferruginous, with a large sterile basal part, firm, cells elliptical, laterally compressed, to 0·5 mm. long, empty; tramal plates 90-150 μ thick, of woven partly gelatinized hyphae, hyaline, slightly scissile; basidia 2-4 spored. Spores globose, a few subglobose, 9-12 μ diameter, or 10-12 x 9-11 μ, shortly pedicelled, epispore fuscus, 1 μ thick, covered with a gelatinous fuscus epispore 1·5 μ thick and strongly areolate, opaque.

Habitat—Buried 35-50 mm. in peaty soil.

Distribution—Victoria. Glenelg River, June 1950, H. H. Finlayson.

Plants were collected upon the surface of the ground, being dug up from their place of origin 1·5-2 in. beneath the surface by small marsupials. In its double peridium, particularly the structure of the exterior layer, the species resembles *Hymenogaster viscidus* (Mass. and Rodw.) Dodge and Zell. It differs in the small size and different shape of the peridium, and globose almost opaque smaller pores.

Secotium fragariosum n. sp.

[1] Peridium pyriforme, 8-12 x 6-12 mm., colore fragorum, tenuiter tuberculosum, obscuratum, hyphis intextis, siccitate brunneo-rubrum, 466-600 μ crassum. Stipes pallide luteus, 5-10 x 0·5-1 mm., aequalis, fibrillosus, cavus. Gleba cellulosa, pallide ferruginea, lamellis tramae 25-75 μ crassis. Sporae ellipticae, rotundis capitibus, 15-19 x 10-13 μ, epispora hyalina, levi, 1·5 μ crassa.

Peridium pyriform, 8-12 mm. tall, 6-12 mm. diameter, apex rounded, base truncate, excavated, or decurrent, exteriorly strawberry-colour, finely tuberculose, dull, drying reddish-brown, 400-600 μ thick when dry, warts to 150 μ tall and broad, of densely woven mainly parallel partly gelatinized hyphae, in section bay-brown, shining and appearing cartilaginous, with pigment granules on walls of the outer hyphae. Stem light yellow, 5-10 x 0·5-1 mm., fibrillose, equal, hollow;

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[1] I am grateful to Miss B. Hooton, Librarian of this Division, for preparing Latin diagnoses.

columella free from the gleba save at the apex. Gleba cellular, pallid ferruginous cells elongate-elliptical, laterally compressed, numerous, to 2 mm. long; tramal plates 27-75 μ thick, of woven mainly parallel hyphae, not scissile. Spores elliptical with rounded ends, with or without a brief pedicel, 15-19 x 10-13 μ, epispore hyaline, smooth, 1·5 μ thick.

Habitat—Growing solitary on the ground amongst grass.

Distribution—Norfolk Island. Cascade Bay, September 1947, W. Cottier.

Specimens were collected growing amongst grass under forest trees and in appearance when fresh closely resembled in colour and shape fruits of wild strawberry. The species shows a general resemblance to small specimens of *S. erythrocephalum* Tul., differing in the roughened peridium, colour, and thick-walled spores.

AUSTRALIAN ACANTHOCEPHALA, NO. 9

BY T. HARVEY JOHNSTON AND S. J. EDMONDS

Summary

1. An account is given of the larval stage of Corynosoma clavatum Goss from the mesentery of a fish, Platycephalus fuscus, South Australia.
2. Micracanthocephalus hemirhamphi Baylis is recorded from a South Australian garfish, Hemirhamphus intermedius.
3. Moniliformis semoni (Linstow) is described from eastern Australian bandicoots, Isoodon torosus, I. obesulus and Perameles nasuta.
4. The large acanthocephalan recorded from introduced species of Rattus in Australia is regarded as Moniliformis dubius Meyer.

AUSTRALIAN ACANTHOCEPHALA, No. 9

By T. Harvey Johnston and S. J. Edmonds *

[Read 10 May 1951]

SUMMARY

1. An account is given of the larval stage of *Corynosoma clavatum* Goss from the mesentery of a fish, *Platycephalus fuscus,* South Australia.
2. *Micracanthocephalus hemirhamphi* Baylis is recorded from a South Australian garfish, *Hemirhamphus intermedius.*
3. *Moniliformis semoni* (Linstow) is described from eastern Australian bandicoots, *Isoodon torosus, I. obesulus* and *Perameles nasuta.*
4. The large acanthocephalan recorded from introduced species of *Rattus* in Australia is regarded as *Moniliformis dubius* Meyer.

We are indebted to Dr. E. A. Derrick, Institute of Medical Research, Brisbane, for material from bandicoots, *Isoodon torosus,* and from rats from south-eastern Queensland. The remainder was collected by the senior author. Mr. W. A. Rainbow, Australian Museum, Sydney, kindly sent us a photograph of Linstow's figures of *Moniliformis semoni.* All measurements given in this paper, unless otherwise stated, are for worms cleared in methyl salicylate. Specimens of the parasites have been deposited in the South Australian Museum.

Corynosoma clavatum Goss (encysted). *Platycephalus fuscus,* St. Vincent Gulf, S. Aust.

Micracanthocephalus hemirhamphi Baylis. *Hemirhamphus intermedius,* Port Willunga, S. Aust.

Moniliformis semoni (Linstow). *Isoodon obesulus,* Sydney, N.S.W.; *Isoodon torosus,* S.E. Qld; *Perameles nasuta,* Gosford, N.S.W.

Moniliformis dubius Meyer. *Rattus rattus,* Brisbane, Sydney; *Rattus norvegicus,* Brisbane, Sydney.

Corynosoma clavatum Goss Fig. 1-3

About twelve larval specimens of *Corynosoma clavatum* Goss (1940) were found attached to the mesentery of a flathead, *Platycephalus fuscus,* caught in St. Vincent Gulf, South Australia, in November 1933. The worms were removed in the encysted form from the fish and the proboscis of all became wholly or partly everted when the organisms were placed in fresh water. Some of the parasites came completely out of their cyst walls. We have had to rely on the size and spination of the proboscis for our identification of the specimens.

The length of the proboscis is 0·69-0·75 mm. and its maximum width is 0·30-0·32 mm. It is armed with 16 rows, each of 10 hooks. The anterior six hooks of each row are larger and bear rooting processes. The size and shape of some of them is shown in fig. 3. The proboscis sheath is double-walled and about 1·0 mm. long.

There is a neck, 0·59-0·70 mm. long and 0·22-0·51 mm. wide at its base. The length of the body of the parasites (measured from the base of the neck) is 2·1-2·6 mm.; and the maximum width is 1·0-1·5 mm. The anterior portion of the body bears numerous small spines. The genital aperture of the completely freed worms is surrounded by a few very small spines.

* University of Adelaide.

C. clavatum has now been reported from a number of hosts in Australia. The adult form was described by Goss (1940) from shags, *Phalacrocorax varius, P. melanoleucus* and *P. ater* from Western Australia. In South Australia the adult has been reported by Johnston and Best (1942) from *P. varius* and from a seal, *Gypsophoca dorifera.*

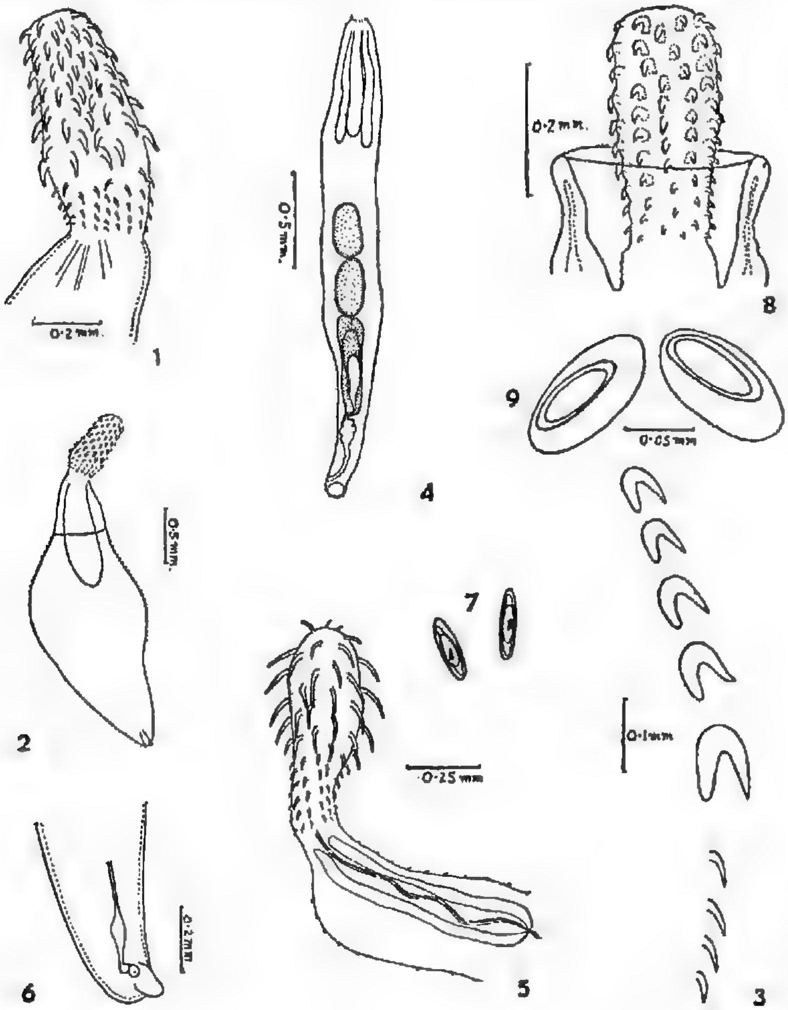

Fig. 1-3—*Corynosoma clavatum:* 1, proboscis of larva; 2, larva; 3, some proboscis hooks. Fig. 4-7—*Micracanthocephalus hemirhamphi:* 4, body of male; 5, proboscis 6, posterior region of female; 7, eggs. Fig. 8-9—*Moniliformis dubius:* 8, proboscis; 9, eggs.

MICRACANTHOCEPHALUS HEMIRHAMPHI Baylis. Fig. 4-7

One male and two female specimens of this parasite were found in the intestine of a garfish, *Hemirhamphus intermedius,* caught at Port Willunga, South Australia, in March 1934. The proboscis of only one specimen, a female, was in a sufficiently satisfactory condition for measuring.

The male specimen is slightly flattened. The length of the body is 2·8 mm. and its maximum width 0·35 mm. The proboscis sac is 0·7 mm. long. Two

testes, arranged in tandem, may overlap each other but not the proboscis sac. The cement glands are pressed closely together and we have been unable to determine their number. The genital aperture is subterminal. There are two lemnisci, each a little larger than the proboscis sac. The anterior region of the body bears about 14 or 15 transverse rows of spines.

The body length of the females is 4·0-4·9 mm. and the maximum width 0·44-0·70 mm. The proboscis, 0·57 mm. long and 0·20 mm. wide, is bent almost at right angles to the body. It is armed with 12 rows of 11 hooks per row (fig. 5). The proboscis sac is 0·70 mm. long and its width is 0·11 mm. In both female specimens there is a finger-like appendage near the genital aperture. The posterior region of the body of our specimen is not sharply bent so as to form a hook as reported by Baylis. The genital aperture is lateral rather than subterminal. Ellipsoidal eggs are 58-60 μ long and 18-20 μ wide.

Macracanthocephalus hemirhamphi was described by Baylis (1944) from the same host species, *Hemirhamphus intermedius,* from Otago, New Zealand.

MONILIFORMIS SEMONI (Linstow). Fig. 10-17

Many specimens of this species from bandicoots, *Isoodon torosus,* from Woombye, Nambour and Cowan Cowan, south-eastern Queensland, were sent to us for identification by Dr. E. H. Derrick.

The parasites are long and either cylindrical or somewhat flattened. The body shows external pseudo-segmentation and at first sight looks like that of a cestode. The width of the worm gradually increases towards the posterior region and in the male is greatest in the region of the testes. The length of the male is 4·6-4·8 cm.; that of the female 10·4-14·0 cm. The maximum width of the male is 2·0 mm., and of the female 1·9 cm.

The small flask-shaped proboscis consists of an armed portion, 0·46-0·56 mm. long, and a short unarmed portion, 0·15-0·17 mm. long. The width of the proboscis anteriorly is 0·26-0·30 mm., and posteriorly 0·17-0·22 mm. It seems most likely therefore that the length of the organ given by Linstow, *viz.,* 0·7 mm., is that of the combined length of the armed and unarmed portions. How to describe the arrangement of the proboscis hooks has proved difficult. There are 12 rows of hooks, each row consisting of three larger anterior hooks arranged longitudinally and provided with strong rooting processes, followed by 10-12 smaller and more slender hooks arranged spirally, *i.e.,* there are 12 rows of about 13-15 hooks per row. In some rows the posterior hooks are arranged somewhat irregularly. Linstow described the species as possessing 21 transverse rows each of 6 hooks, and Meyer has suggested 12 rows of 10-11 hooks. Neither of these descriptions seems to us to be satisfactory. The number of hooks is greater than that given by these two workers.

The maximum length of the double-walled proboscis sheath is 1·2 mm. and its maximum width 0·4 mm. An elliptical ganglion is situated at its base. There are two long coiled lemnisci. The body wall is thick and appears to contain only one collecting vessel in the lacunar system.

Two elliptical testes of approximately equal size are situated in the posterior region of the male. Their maximum length is 3·8 mm. and width 1·4 mm. The cement glands are elliptical or flask-shaped and are closely packed together. In two specimens they overlap the posterior testis, but this may have occurred during fixation. The glands in our specimens are so tightly pressed together that we were unable to determine directly their number. The ducts from the cement glands, however, do not fuse but run separately to the bursa. In some males the

posterior region is flexed and flattened at about the level of the cement glands. Saefftigen's pouch is about 1·7 mm. long. There are well-developed penis and bursa. The genital aperture is terminal.

The female genitalia, consisting of uterus and vagina, are about 1·0 mm. long in the adult. The vagina is a short, stout structure. Eggs mounted in Canada balsam are 70-80 μ long and 32-36 μ wide.

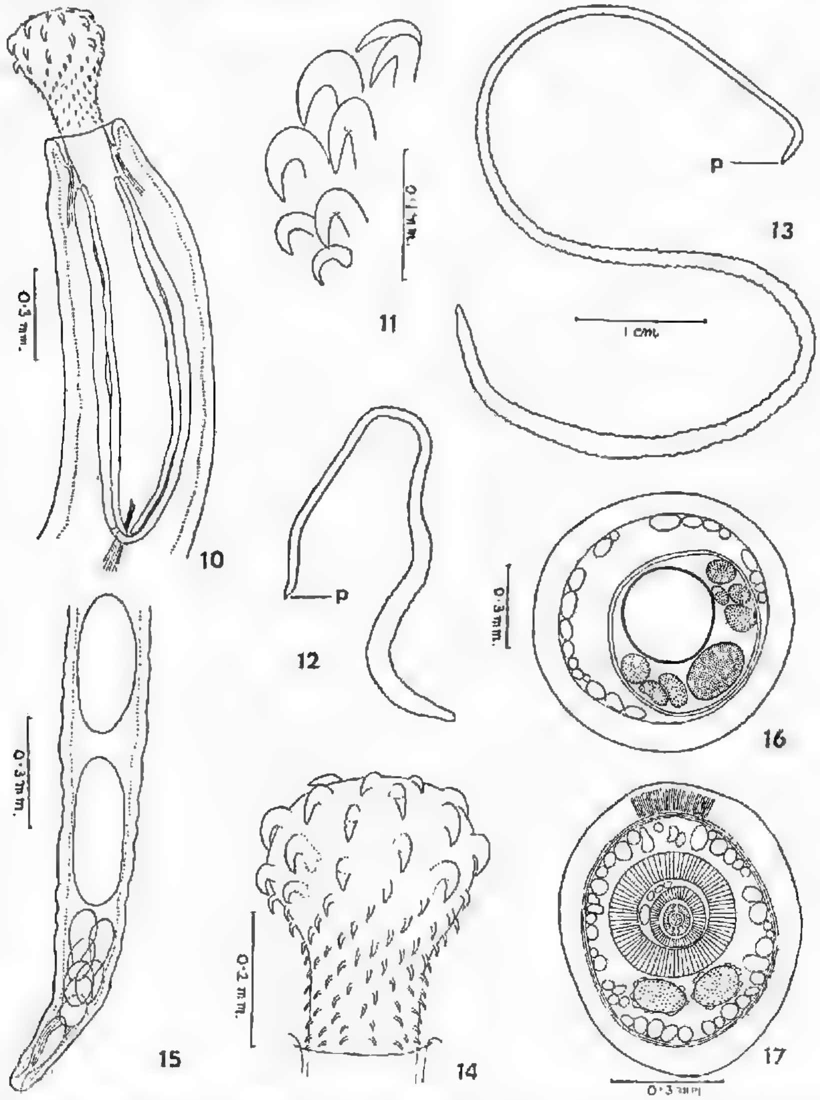

Fig. 10-17—*Moniliformis semoni*: 10, anterior region; 11 some proboscis hooks; 12, adult male; 13, adult female; 14, proboscis; 15, posterior region of male; 16, T.S. through cement ducts; 17, T.S. through proboscis sac. Fig. 12 and 13 are drawn to same scale.

Systematic position

This species was described as *Echinorhynchus* (*Gigantorhynchus*) *semoni* by Linstow (1898, 469-471), from *Perameles obesulus* from the Upper Burnett River region in south-eastern Queensland. Porta (1908) and Johnston (1909, 521) transferred it to *Gigantorhynchus*, the latter recording the parasite from

the same host species, *Isoodon obesulus*, from Sydney. Johnston (1911, 50; 1910, xvii) also reported the presence of *Gigantorhynchus* sp. (? *G. semoni*) in *Perameles nasuta* from Gosford, New South Wales; and *Gigantorhynchus* sp. in *Phascogale penicillata* in New South Wales (1910, xvii; 1911, 50). The material from *P. nasuta* belongs to *M. semoni* and that from *Phascogale* probably belonged to the same species. Travassos (1917, 25) transferred the species to *Prosthenorchis*. Johnston and Deland (1929, 146) left it under *Gigantorhynchus*. Meyer (1932) placed it in an appendix to the Moniliformidae. We consider that the species belongs to *Moniliformis*.

Moniliformis dubius Meyer. Fig. 8-9

About 25 specimens of an echinorhynch identified by us as *Moniliformis dubius* Meyer 1932 were examined. The material was collected from *Rattus rattus* and *R. norvegicus* by Dr. Derrick from Brisbane and by the senior author from rats at Brisbane and Sydney. We were unable to notice any significant difference between the material from the different hosts.

The worms are long and usually moniliform. The length of the males is 2·8-4·2 cm., and of the females 2·0-16·4 cm. The maximum width of the male is about 1·5 mm., and of the female 2·3 mm., excluding the flattened specimens. The proboscis of most specimens is almost cylindrical, but in a few specimens it is rather club-shaped. It varies rather considerably in length, being 0·42-0·53 mm. long, and consisting of an armed portion 0·36-0·48 mm. in length and a small unarmed portion 0·03-0·07 mm. long. Its maximum width is 0·17-0·19 mm. The proboscis is armed with 12 longitudinal rows of hooks, 10-11 hooks per row. The size, shape and arrangement of these hooks is shown in fig. 8.

The proboscis sheath is sac-like, about 0·7 mm. long and bears spiral striations. The lemnisci may be 3·5 mm. in length. Two testes, 1·7-2·5 mm. long and 0·40-0·65 mm. wide, lie in the posterior region of the male. The cement glands are pressed closely together and the male genital aperture is terminal. Van Cleave (1924), when describing the eggs of his *M. moniliformis*, which according to Meyer (1932) and Chandler (1941) is synonymous with *M. dubius*, says: "The outer embryonic membrance is not a firm, highly resistant shell, such as is found in most species of Acanthocephala. On the contrary, it is rather delicate and subject to much distortion." This describes exactly the condition noticed in the eggs of most of our specimens. The outer membrane is 109-118 μ long and 46-57 μ wide. Within this membrane lies a thicker elliptical shell, 76-84 μ long and 30-38 μ wide.

After studying a large number of moniliform Acanthocephala collected from rats in different parts of the world, Van Cleave (1924) came to the conclusion that the material which he had examined was identical with that of *M. moniliformis* (Bremser 1811). He redescribed the species and extended the range of measurements of some organs.

Meyer (1932) recognised three closely-related species of moniliform Acanthocephala from rodents: — (1) *M. moniliformis* (Bremser 1811); (2) *M. dubius* (syn. *Moniliformis* sp. Chandler 1921; and *M. moniliformis* Van Cleave 1924); and (3) *M. travassosi* (syn. *M. moniliformis* Travassos 1917). In addition he admitted three geographical variations within the species *M. moniliformis* (Bremser).

Chandler (1941) considered that his *Moniliformis* sp. from the Texas rat was synonymous with *M. dubius* Meyer 1932, *i.e.*, that the name *dubius* was valid. He went on to say that in his opinion *M. travassosi* Meyer 1932 was synonymous with *M. dubius*.

Our study of a limited number of specimens, unfortunately, does not help much towards solving the problem of the number of valid species. The dimensions of the proboscis of our specimens lie between those of *M. moniliformis* (Bremser) and *M. dubius* Meyer. As the number and arrangement of the proboscis hooks and the size and shape of the eggs of our specimens are similar to those of *M. dubius*, we have placed our parasites under *M. dubius*. The parasite recorded as *Hormorhynchus moniliformis* by one of us from rats in Sydney, Brisbane and North Queensland (Johnston 1909; 1912; 1913; 1918) is also *M. dubius*.

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AN ENUMERATION OF THE VASCULAR PLANTS OF KANGAROO ISLAND : SECOND LIST OF ADDITIONS AND CORRECTIONS

BY J. B. CLELAND AND J. M. BLACK

Summary

In the "Transactions of the Royal Society of South Australia," 65, (2) 1941, we gave a list of Additions and Corrections to our Enumeration of the Plants of Kangaroo Island. Various additions have been made since that date and the appearance of the second edition of Parts I and II of Black's Flora of South Australia has led to various alterations in nomenclature.

AN ENUMERATION OF THE VASCULAR PLANTS OF KANGAROO ISLAND

Second List of Additions and Corrections

By J. B. Cleland and J. M. Black

[Read 14 June 1951]

In the "Transactions of the Royal Society of South Australia," 65, (2) 1941, we gave a list of Additions and Corrections to our Enumeration of the Plants of Kangaroo Island. Various additions have been made since that date and the appearance of the second edition of Parts I and II of Black's Flora of South Australia has led to various alterations in nomenclature.

The total number of vascular plants recorded from Kangaroo Island now comes to 856 with 29 varieties in addition, of which 725 and 27 varieties in addition are natives and 131 and 2 varieties are introduced.

Attention has been called by others to the absence of kangaroo grass (*Themeda australis*) from Kangaroo Island. It is also remarkable that no species of *Lomandra* has been recorded.

It is of interest to compare the number of plants now known from Kangaroo Island with those of an area on the adjacent mainland, namely the Encounter Bay district. In the "South Australian Naturalist" from time to time we have recorded the species found there; the Sixth List of Additional Records has been prepared and will, we hope, be soon published in that periodical. The area extends from the Tunkalilla Road in the west to Currency Creek in the east and embraces the catchment areas of the Inman and Hindmarsh Rivers. The Surveyor-General, Mr. A. D. Smith, has kindly had estimated for us the size of this area which is 233 square miles. The area of Kangaroo Island is 1,680 square miles. For the Encounter Bay District 948 species and 21 varieties have been noted, of which 705 species and 18 varieties are natives and 243 species and 3 varieties introduced. Thus, though the area of the Encounter Bay District is less than one-seventh of that of Kangaroo Island, 705 species of native Australian plants are now recorded, nearly the same as on Kangaroo Island (725). As might be expected, the introduced plants are nearly double those of the Island.

In the following list, an asterisk (*) indicates an introduced species.

Filicales

Hypolepis rugulosa, Ravine des Casoars at the Cape Borda road, Feb. 1950.

Gramineae

**Stenotaphrum secundatum* (buffalo grass), C. de Couedic. **Ehrharta longiflora*. **Phalaris tuberosa* (Toowoomba canary grass). *Stipa semibarbata* var. *gracilis* in Black's Flora. *Echinopogon ovatus*, already recorded, also Rocky River. *Agrostis Billardieri* replaces *Calamagrostis filiformis* var. *Billardieri*, and *A. avenacea* replaces *C. filiformis*. *A. aemula*, Rocky River. *Deyeuxia quadriseta* replaces *C. quadriseta*, and *D. minor* replaces *C. minor*. **Avena barbata* (bearded oat). *Amphibromus Neesii* replaces *A. nervosa*. *Distichlis distichophylla* replaces *D. spicata*. *Poa poaeformis* replaces *P. caespitosa* var. *Billardieri*. *Poa tenera*? Stunsail Boom and Rocky Rivers. **Bromus mollis*, as well as **B. hordeaceus*. **Vulpia bromoides* replaces *Festuca bromoides*. **Scleropoa rigida* replaces *F. rigida*. **Lolium subulatum*, Kingscote. **Lepturus cylindricus*, Kingscote. **Pholiurus incurvus*, Kingscote, Vivonne Bay.

Cyperaceae

Schoenus nitens, already recorded, Rocky River, identified by S. T. Blake as "forma". *Scirpus validus,* S.W. River. *Carex breviculmis,* Rocky River 24 Nov. 1945, identified by S. T Blake.

Restionaceae

Lepyrodia valliculae, perhaps the "*Lepyrodia* sp." of Tepper.

Liliaceae

**Asparagus medeoloides,* White's Lagoon. *Reya umbellata* replaces *Burchardia umbellata,* flowers unusually small at Seddon. **Allium Ampeloprasum.* **A.* sp., roadside near Kingscote.

Iridaceae

**Watsonia Meriana,* densely established around the cemetery at Harvey's Return, probably also at Vivonne Bay. **Romulea* sp. **Moraea xeerospatha* var. *monophylla.*

Casuarinaceae

Casuarina quadrivalvis. Large groves of sheoaks, often in pure sand, clothe the upper parts of the sides of watercourses such as Breakneck, Sandy, West Bay and the Ravine. The trunks may be one to three or four; the trees spread slightly fanwise. The habit is unlike that of trees on the mainland which are usually widely separated from each other.

Proteaceae

Hakea Muelleriana replaces *H. ulicina* var. *flexilis. Grevillea muricata* is a synonym of *G. Rogersi. G. aspera* requires confirmation.

Santalaceae

Eucarya replaces *Fusanus.*

Polygonaceae

**Emex australis.*

Chenopodiaceae

Chenopodium pumilio replaces *Ch. carinatum.* **Ch. album,* Rocky River. *Ch. ambiguum* replaces *Ch. glaucum. Threlkeldia diffusa,* already recorded, also at mouths of Stunsail Boom River and Ravine des Casoars. *Salicornia Blackiana,* coast on Flinders Chase, previously recorded as doubtful.

Amaranthaceae

**Amaranthus albus,* Cape Borda.

Aizoaceae

Tetragonia expansa, Cape Borda, probably a garden escape.

Portulacaceae

Portulaca oleracea (purslane).

Caryophyllaceae

Polycarpon tetraphyllum.

Cruciferae

**Diplotaxis tenuifolia,* already recorded, also Kingscote. *Lepidium hyssopifolium. Lepidium pseudo-ruderale* is given by Black only for our North; perhaps this should be *L. halmaturinum. Stenopetalum* sp., near Rocky River. *Cakile edentula* is given by Black for Kangaroo Island, not *C. maritima;* plants at Kingscote have pinnatipartite leaves and fruits with or without horns—the two species seem to intergrade.

LEGUMINOSAE

Acacia euthycarpa in Black's Flora. *A. Sophorae* replaces *A. longifolia. Daviesia pectinata* requires confirmation. *Pultenaea largiflorens* var. *latifolia* in Black's Flora. **Trifolium subterraneum*. **Medicago truncatula*, Kingscote, Rocky River. *Hardenbergia violacea* replaces *H. monophylla.*

GERANIACEAE

**Erodium moschatum*, Cape Borda. *Pelargonium inodorum* replaces *P. australe* var. *erodioides.*

RUTACEAE

Correa rubra var. *orbicularis* and var. *puchella,* both in Black's Flora. *C. minor* replaces *C. rubra* var. *glabra.*

EUPHORBIACEAE

Beyeria Leschenaultii var. *latifolia* in Black's Flora.

RHAMNACEAE

Cryptandra tomentosa in Black's Flora. *C. amara* in Black's Flora.

MYRTACEAE

Eucalyptus viminalis var. *Huberiana* seems to be the form of *E. viminalis* at least at Rocky River. *E. rugosa* (R. Br.) Blakely. *E. Lansdowneana* (= *E odorata* var. *erythandra*).

UMBELLIFERAE

Trachymene heterophylla var. *Teppcri*—in Black's Flora. *Eryngium vesiculosum,* already recorded. On Febuary 1 1950 in a drying swamp near the mouth of S.W. River, a number of young plants were coming up which had narrow "jointed" leaves (like those of *Lilaeopsis,* which they were at first thought to be). They had a parsley-like taste and were not rigid like the older leaves. In "The Victorian Naturalist," 66, (10), p. 197, February 1950, T. S. Hart has an article entitled "Heterophylly in the Prickfoot (*Eryngium vesiculosum*) in which he notes that the young leaves are hollow and subulate and several inches long. Black, in his description of *E. Plantagineum,* recorded from near Cooper's Creek, notes that the leaves may be "linear, flaccid and grasslike . . . . compressed-hollow and marked with distant transverse partitions."

EPACRIDACEAE

Conostephium halmaturinum—a new species (and a new genus for the State) described by J. M. Black, Seddon, February 6 1948.

OLEACEAE

**Olea europaea* (olive), Kingscote.

APOCYNACEAE

**Vinca major.*

CONVOLVULACEAE

**Convolvulus arvensis,* Kingscote.

LABIATAE

**Stachys arvensis.*

COMPOSITAE

Helichrysum apiculatum var. *minus* Benth., identified by J. M. Black, road to Cape de Couedie, February 3 1948. *Picris hieracioides* var. *squarrosa,* Kingsvote, along the cliffs near the sea; this is evidently R. Tate's record of *P. hieracioides,* and as it is a native variety the * should be deleted.

ON A NEW FORM OF HETERONYMPHA PENELOPE WATERHOUSE (LEPIDOPTERA RHOPALOCERA, FAMILY SATYRIDAE)

BY NORMAN B. TINDALE

Summary

A description is given of a new race, Heteronympha penelope maraia from the Grampian Mountains, western Victoria. H. p. panope is recorded from altitudes of 2,400-3,800 feet on Mount Barrow in the north-eastern highlands of Tasmania. There is a discussion on the possible climatic significance of the development in isolation of six different races of this butterfly in south-eastern Australia and Tasmania.

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By Norman B. Tindale *

[Read 14 June 1951]

SUMMARY

A description is given of a new race, *Heteronympha penelope maraia* from the Grampian Mountains, western Victoria. *H. p. panope* is recorded from altitudes of 2,400 - 3,800 feet on Mount Barrow in the north-eastern highlands of Tasmania. There is a discussion on the possible climatic significance of the development in isolation of six different races of this butterfly in south-eastern Australia and Tasmania.

Heteronympha penelope Waterhouse

Visiting Tasmania in January and February 1948 I took a long series of *Heteronympha penelope panope* Waterhouse, of both sexes, on Mount Barrow in north-eastern Tasmania, at elevations of 2,400 - 3,800 feet, on 9 February. They were flying in natural grassy meadows just below a belt of Antarctic beech forest on the north-eastern slope of the mountain, also above it; all were freshly-emerged specimens. In November 1950 some *H. penelope* larvae were taken, feeding at night on soft native grasses, *Poa caespitosa* and *Danthonia pilosa*, on the banks of Fyans Creek, Grampians, western Victoria. When reared they proved to be a new form of this butterfly.

These finds drew my renewed attention to the species, which, as Waterhouse (1937) had already realised, shows considerable variation in form and markings, in the several isolated areas in which it occurs.

The following races previously have been described, all by G. A. Waterhouse:—

(1) *Heteronympha penelope penelope* Waterhouse 1937. From New South Wales at Barrington Tops, in January and February, also from Stonehenge, Ebor (4,800 feet), the Blue Mountains, Moss Vale, and on Mount Kosciusko at 5,000 feet, in February. The type locality is at Barrington Tops.

(2) *Heteronympha penelope sterope* Waterhouse 1937. From Gisborne and Fern Tree Gully, eastern Victoria, flying from January to March.

(3) *Heteronympha penelope alope* Waterhouse 1937. Lorne, Victoria, in February and March.

(4) *Heteronympha penelope diemeni* Waterhouse 1937. The holotype is from New Norfolk near Hobart in February; it is known also from above Hobart, on the slopes of Mount Wellington (at elevations up to 1,000 feet), at Dunally, and on Maria Island. Waterhouse also placed here a female from Launceston (February) and a worn pair taken at Burnie. There are in the South Australian Museum collection several specimens, labelled (Launceston, F. M. Littler), including one taken in March.

(5) *Heteronympha penelope panope* Waterhouse 1937. Cradle Mountain, western Tasmania (2,000 feet), at Derwent Bridge near Lake St. Clair and Mount Magnet (in January). Only the male is so far described; Mr. L. Couchman has in preparation a detailed study of dates of capture and localities in Tasmania.

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* South Australian Museum.

Heteronympha penelope maraia subsp. nov.
Plate II

Male—Forewings black, with rich orange-brown markings; a large ocellus below apex partly surrounded above by orange-brown, and with an orange-brown spot below it; a large similarly coloured patch in upper half of cell, broadly connected to another orange-brown patch extending nearly to inner margin and to base of wing; the latter is partly divided by a thin black band at about one-half; sex scales in cell grey, with a prominent black spot defining their distal limit. Hindwing broadly orange-brown, with a large ocellus near inner angle and a small black spot below costa representing a vestige of a subapical one, without defined centre; a very limited black area in centre of wing. Forewings beneath with pattern of markings as above, but with apical fifth of wing chocolate-brown, ocellus with a double ring and light areas pale orange, lighter towards costa; cell orange, with a conspicuous black circular patch at one-half, and an angled black patch partly margining apex of cell. Hindwings pale chocolate-brown with a broad outer chocolate margined area possessing a purple sheen and connecting the two eye-spots; the subapical eye-spot small, one at inner angle relatively large. Expanse 60 mm.

Female—Similar to male, but with outer margin straighter and inner angle of hindwing more acute; base of wings infuscated with patches of dark scales, obscured by long hairs, so as to appear grey; brown area above subapical ocellus of forewing conspicuously dark; subapical ocellus of hindwing with traces of a white centre; wings below slightly paler than in male and patch below subapical ocellus of forewing almost white. Expanse 67 mm.

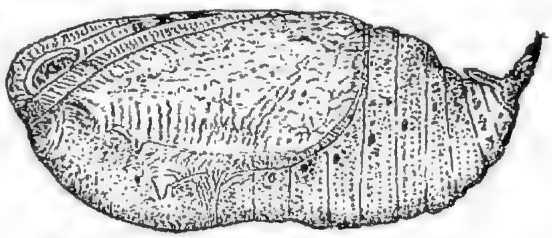

Fig. 1

Locality—Western Victoria; Fyans Creek, Grampian Mountains (800 ft.). Holotype a male, emerged 26 January 1951, and allotype female, emerged 30 January 1951 (I. 19088 in S.A.M.), collected and presented by N. B. Tindale, also a paratype male, emerged 25 January 1951, and 5 males and 4 females from there and from Mount Rosea, January-February 1952. The name suggested for the race is based on the aboriginal word "Maraia," a Marditjali tribe name for the Grampian Mountains.

This race differs from the others of the species in the great extent of the rich brown colour of the wings, in both sexes, and the relative absence of dark infuscations on the hindwings above. In its wing markings it is nearest to *H. p. sterope*, sharing with most examples of that form the interconnected orange-brown areas of upper cell and tornal regions. It differs in detail of markings. The tips to forewings beneath, and hindwings, instead of the relatively pale ochreous colour characteristic of the Eastern Victorian race, are rich brown.

In *H. p. maraia* the brown of the ground colour in the female is almost as dark as in the male, whereas in *H. p. sterope*, as also in *H. p. diemeni*, the female is by far the paler of the two.

From *H. p. alope* and *H. p. panope* it differs in its relatively larger size, and in having the spot immediately below the subapical ocellus of the forewing

above, deep orange-brown in both sexes, instead of pale brown in the male, and white in the female as in these often smaller forms. It also differs in having a single small subapical eye-spot on the hindwing, almost devoid of white centre, instead of the biocellate subapical condition usual in the Tasmanian form. In this character it resembles *H. p. alope.*

Life-history—Eggs and larvae have been examined and agree with Waterhouse's description of those of the eastern races. The pupa (fig 1) is 17 mm. in length, robust, pale brown in colour. Some pupae have dark spots and blotches. Pupation takes place among a few strands of loose silk, embracing leaves. The pupa figured, that of the allotype female, emerged after an interval of 41 days.

Key for the Separation of Races of Heteronympha penelope

1	Size large (60 mm. or over)		2
	Size small (below 55 mm.)		5
2	Orange spot in cell of forewing connected with that of dorsum		3
	Orange spot in cell of forewing not connected with that of dorsum		4
3	Tip of forewing beneath brown	*maraia*	
	Tip of forewing beneath pale ochreous	*sterope*	
4	Wings strongly angulate	*penelope*	
	Wings somewhat rounded	*diemeni*	
5	Hindwings uniocellate	*alope* (male)	
	Hindwings biocellate		6
	Hindwings triocellate	*panope* (most)	
6	Wings with dark markings dominant	*panope*	
	Wings with ochreous markings dominant	*alope* (female)	

Note—The above key is intended to separate all but an occasional variant. Some *H. p. sterope* have the discoidal spot partly divided from that of dorsum by a few dark scales. Mr. L. Couchman tells me he has specimens of *H. p. alope* much larger than here indicated, and that, in a long series, *H. p. alope* appears to intergrade with *H. p. sterope.* Such large *H. p. alope* specimens will, in this key, fall out with *H. p. sterope.*

Discussion on the Forms of Heteronympha penelope

It seems possible that *H. p. panope* and *H. p. alope* form a natural group of slightly smaller races with well-rounded wings in both sexes, while the *H. penelope* series, *penelope, sterope, diemeni* and *maraia* comprise generally larger forms with more angular wings; the last-named character is especially noticeable in the females, and least evident in the males of *diemeni.*

At first it was thought that the *panope* and *penelope* series might be two separate species, but this appears not to be the case.

H. p. panope, in general, tends to be a mountain form in northern Tasmania, appearing for a brief season in January and early February at rather high elevations. On Mount Barrow it appears abundantly just below an Antarctic beech forest zone; and also up beyond it to the bare rock slopes at 3,800 feet. It also occurs in the uplands of western Tasmania, where it breeds at elevations of over 2,000 feet.

On the broad lowland belt between these two highland areas and extending across the somewhat drier and relatively low midland region of Tasmania from Launceston to Hobart, as well as on islands such as Maria Island, occurs the larger, more angular-winged *H. p. diemeni* which emerges in late January, February and early March; this form is rather closely related to *H. p. sterope* of the foothills of Eastern Victoria.

H. p. alope of the Lorne area seems to be the mainland representative of the *panope* series, but this tentative conclusion may be modified when more material is available from the Lorne district.

The presence in Tasmania of a mountain form, *panope*, occupying two separate areas, formerly completely glaciated, with a different race, *diemeni*, in the always unglaciated country of the broad, generally lowland belt, in between, opens up interesting avenues for speculation on the possible late Pleistocene and Recent history of the species in south-eastern Australia.

Judging from present-day capacities of *panope* larvae to resist cold it is possible that the late Pleistocene ancestor of the *panope* form was able, during the Wurm (Last) Glaciation to maintain its footing either in the area of the present northern Tasmanian lowlands, or at least in the lowlands now under the ocean, of which King Island is a relic. Perhaps the capacity of this ancestral form to resist cold may have been brought about by gene selection during the onset of that or earlier glacial episodes.

As climate began to ameliorate in Recent time the ancestral *panope* began slowly to recolonise the Eastern and Western Highlands, and, except in the south, eventually perhaps abandoned the warmer lowlands in between as these became too mild or otherwise unsuitable. Thereafter eastern and western population of *H. p. panope* perhaps developed in isolation from each other. If so, the interval of time since they became separated has not been great enough to cause them to become greatly differentiated. It has not been possible to find consistent characters to separate them.

Perhaps later than the postulated separation of the two *panope* populations, the large and rather different Victorian ancestor of *sterope* found its way south to Tasmania, following the extension southwards of the warmer climatic belt. Since this form may have become, or remained adjusted to a warmer climatic range than ancestral *panope* it came to breed in, and occupy, the lowlands of Tasmania.

As Tasmania became cut off by the Post-Glacial rise in sea-level it has been differentiated a little from the Victorian *sterope*, and today appears as the large form *diemeni*.

Only in some such way does it seem possible to account for the presence of two separate races of *H. penelope* in Tasmania.

The presumptively lowland and highland breeding forms seem to have remained isolated from each other and to have been sufficiently free of recent gene exchange to have maintained characteristic appearances.

There is a possibility that *panope* may appear a little earlier than *diemeni*. The insects fly at a period of the year of maximum warmth and dryness, considering the relatively wet environment of Tasmania. They are not far-ranging forms and probably do not fly far from the natural banks and meadows in which they breed.

When more intensive collecting is done, however, it may be found that at a few places there have arisen natural hybrid populations, *panope x diemeni* after the manner of the natural hybrid *Tisiphone abeona joanna* reported by Waterhouse (1928) in northern New South Wales. In such a case it would not be surprising to find a very variable local population, similar to that which was established to be of hybrid origin by the breeding experiments made by Waterhouse on neighbouring races of *Tisiphone abeona*.

It was at first thought that the eastern and western *panope* populations might be distinguishable, but examination of the very long series taken on Mount Barrow and of the majority of the known specimens from the western highlands convinced me they cannot be separated, for, unlike most of the other established races, it does not seem possible to find any character sufficiently different and stable to enable them to be keyed apart.

Either the rigid selection which enabled *panope* to survive in its cold environment has restricted its genetic plasticity, as compared with mainland races, or the

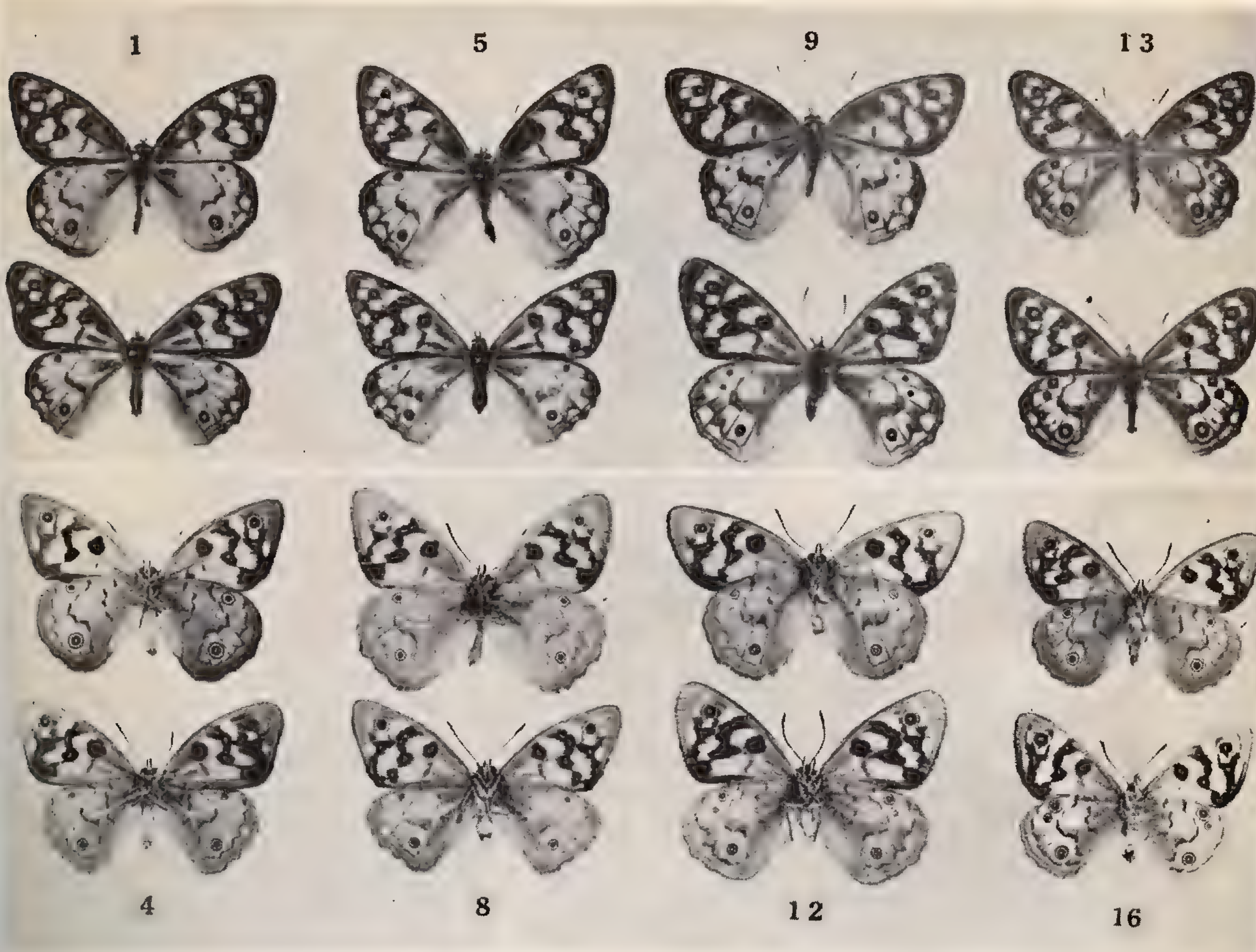

Fig. 1-16 *Heteronympha* penelope Waterhouse (x $\frac{4}{5}$ nat. size)

Fig. 1	*H. p. maraia* Tindale,	male, upper surface, Fyans Creek, Victoria	
Fig. 2	„ „ „	„	female, upper surface, Fyans Creek, Victoria
Fig. 3	„ „ „	„	male, lower surface, Fyans Creek, Victoria
Fig. 4	„ „ „	„	female, lower surface, Fyans Creek, Victoria
Fig. 5	*H. p. sterope* Waterhouse,	male, upper surface, Fern Tree Gully, Victoria	
Fig. 6	„ „ „	„	female, upper surface, Gisborne District, Victoria
Fig. 7	„ „ „	„	male, lower surface, Fern Tree Gully, Victoria
Fig. 8	„ „ „	„	female, lower surface, Gisborne District, Victoria
Fig. 9	*H. p. diemeni*	„	male, upper surface, Launceston, Tasmania
Fig. 10	„ „ „	„	female, upper surface, Launceston, Tasmania
Fig. 11	„ „ „	„	male, lower surface, Launceston, Tasmania
Fig. 12	„ „ „	„	female, lower surface, Launceston, Tasmania
Fig. 13	*H. p. panope*	„	male, upper surface, Mt. Barrow (3,800 ft.), Tas.
Fig. 14	„ „ „	„	female, upper surface, Mt. Barrow (2,475 ft.), Tas.
Fig. 15	„ „ „	„	male, lower surface, Mt. Barrow (3,800 ft.), Tas.
Fig. 16	„ „ „	„	female, lower surface, Mt. Barrow (2,475 ft.), Tas.

interval of time of separation of the two populations has been too small to allow the appearance of recognisable differences of the type considered by present-day Lepidopterists to be of subspecific value.

What may be a similar or slightly greater interval of time, however, has permitted *sterope* and *diemeni* to develop small though appreciable differences. Did the "mainland" forms retain greater genetic plasticity? Another possibility is that *diemeni* is a natural hybrid, compounded of early crosses of ancestral *panope* and *sterope*.

H. p. maraia of the Grampians is probably the western geographical isolate of the ancestral *sterope* form. The same climatic factors which are postulated by Tindale (1947, 1949) as responsible for the development in the Grampians area of the geographical races *Oreixenica kershawi kanunda, Tisiphone abeona antoni* and several other moisture-loving butterflies, seem to have been responsible for the development of this striking race.

The nymotypical race *H. p. penelope* happens to be the larger and rather isolated form found on Barrington Tops in northern New South Wales. When the *penelope* faunas of areas between there and southern Victoria are better known, other forms may be found connecting *penelope* and *sterope*.

There is at present no foundation for garbled early reports that *H. penelope* had been taken in Western Australia and South Australia. Naturalists should make careful collections in favourable localities between January and March to ensure that it is not somewhere being passed over as the common *Heteronympha merope*.

ACKNOWLEDGMENTS

I am indebted to Messrs. J. C. Le Soeuf and B. Given, my companions on the visit to the Grampians, and to Messrs. L. Couchman and F. E. Wilson for reading through my paper and offering most useful criticism.

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SOME NEMATODES FROM AUSTRALIAN BIRDS AND MAMMALS

BY T. HARVEY JOHNSTON AND PATRICIA M. MAWSON

Summary

1. Austrofilaria rhipidurae n. sp., is described from Rhipidura leucophrys, Adelaide, differing in the form of the vestibule and length of spicules from the only other known species in the genus, A. vestibulata.
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3. An amplified description of Tetrameres australis from the black swan, and an account of some of its growth stages are given.
4. Cosmocephalus australiensis n. sp., is described from water rats, Hydromys chrysogaster.
5. Occurences of various Ascaridate, Spirurate, Filariate and Strongylate worms are recorded from Australian hosts.

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(Read 14 June 1951)

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HOST-PARASITE LIST

Mammals

Gypsophoca tasmaniensis Scott and Lord:—*Contracaecum osculatum* (Rud.); *Stomachus* sp. immature. Lady Julia Percy Island, Victoria.

Vulpes vulpes L.:—*Uncinaria stenocephala* Raill. Adelaide.

Hydromys chrysogaster Geoff.:—*Cosmocephalus australiensis* n. sp.; *Spirura* (s.l.) sp. South Australia.

Macropus major Shaw:—*Hypodontus macropodis* Mönnig, N.S.W.; *Pharyngostrongylus alpha,* Naranders, N.S.W.

Macropus rufus Desm. (albino):—*Pharyngostrongylus alpha* J. and M. Adelaide Koala Park, but originally from Mount Pleasant, S. Aust.

Isoodon torosus Ramsay:—*Echinonema cinctum* Linstow; *Subulura peramelis* Baylis. South-east Queensl.

Birds

Diomedea (Thalassarche) chrysostoma Forster:—*Seuratia shipleyi* (Stoss.); *Stegophorus diomedeae* (J. and M.); *Diomedenema diomedeae* n. g., n. sp. Brighton, S. Aust.

Falso peregrinus Tunstall:—*Serratospiculum guttatum* (Schn.). Kangaroo Island, S. Aust.

Chenopis atrata Lath.:—*Tetrameres australis* J. and M. Tailem Bend, S. Aust.

Rhipidura leucophrys Lath.:— *Austrofilaria rhipidurae* n. sp. Adelaide, S. Aust.

We acknowledge assistance in regard to material from Dr. H. Derrick, Queensland Institute of Medical Research, Brisbane; Messrs. A. Rau, South Australian Museum; G. G. and Bryce Jaensch, Tailem Bend, South Australia; H. M. Gordon, McMaster Laboratory, Sydney; and J. McNally, Fisheries and Game Department, Victoria. The material from an albatross was obtained by one of us from a bird washed ashore at Brighton, South Australia, after a storm. The work has been assisted by a State Research Grant to the University of Adelaide. Types of new species are being deposited in the South Australian Museum.

* University of Adelaide.

Austrofilaria rhipidurae n. sp.

(Fig. 1-3)

Several filarial worms were taken by Mr. A. Rau from behind the eye of a willy-wagtail, *Rhipidura leucophrys,* Adelaide. Males up to 14·7 mm. long; females to 28 mm. Anterior end rounded, with four large oral papillae. Oral aperture sometimes on small projection (fig. 2). Vestibule present, with strongly chitinized walls and narrow lumen.

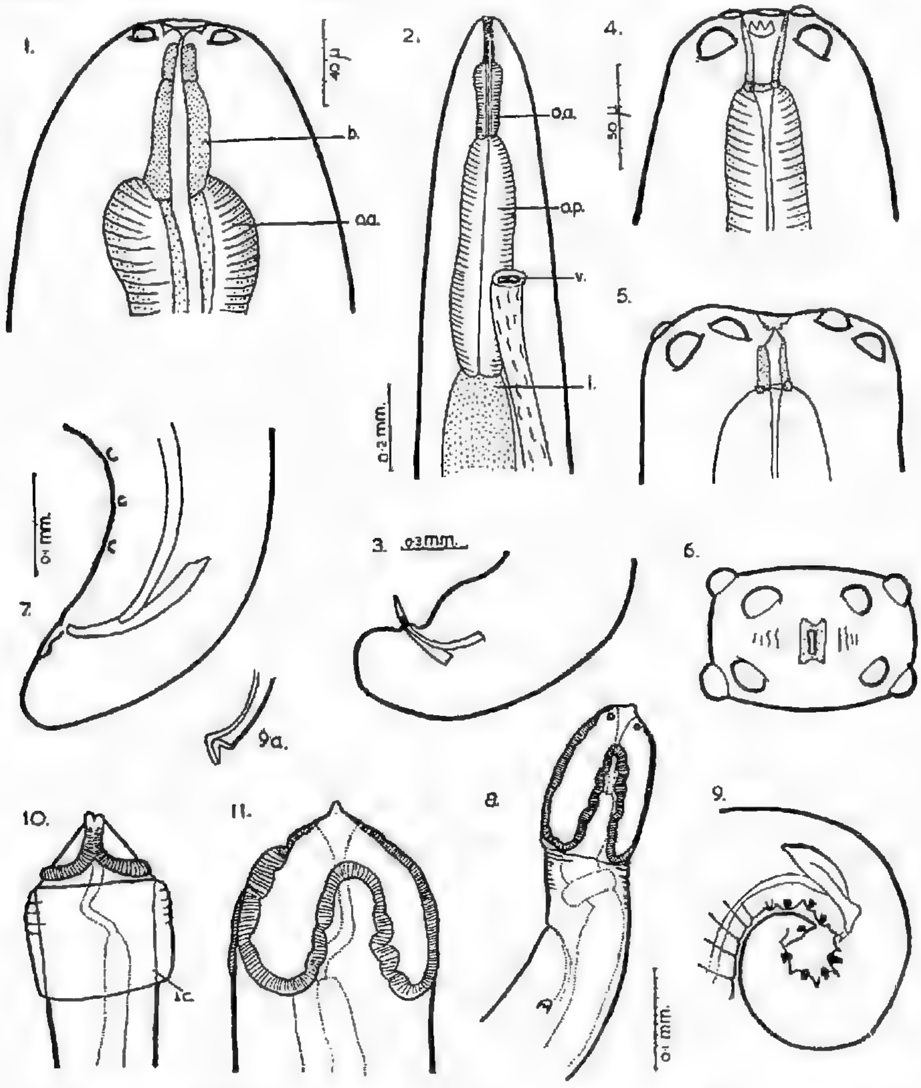

Fig. 1-3
Austrofilaria rhipidurae—1, head of female; 2 oesophageal region; 3, male tail.

Fig. 4-7
Diomedenema diomedeae—4, 5, 6, head in lateral, dorsal and in face views respectively; 7, male tail.

Fig. 8-11
Cosmocephalus australiensis—8, head of adult; 9, male tail; 9a, tip of longer spicule; 10, 11, heads of worms 3·4 and 6·3 mm. long respectively. Fig. 4, 5, 6 to same scale; 1, 10, 11 to same scale; 8, 9 to same scale. b, buccal capsule; i, intestine; ic, inflated cuticle; oa, op, anterior and posterior regions of oesophagus; v, vulva.

Walls consisting of anterior region 19μ long, and posterior part 53μ long. Oesophagus ·7 mm. long, narrower anterior part ·16 mm. long with strongly cuticularized lining which appears to be continuous with the vestibule; posterior part ·55 mm. long. Vulva in oesophageal region, ·6 mm. from head end. Eggs 50μ by 26μ, with embryos 65μ long; anus close to rounded tip of tail. Male tail coiled into short spiral; spicules equal, ·5 mm. long; no gubernaculum, caudal papillae absent.

The genus, originally erected for *A. vestibulata* from *Aphelocephala nigricincta*, appears to be near *Litomosoides* Chandler, resembling it in the presence of a subdivided vestibule whose posterior part seems to be encircled by the anterior portion of the oesophagus; but it is distinguished by the form of the spicules, the presence of oral papillae, and the position of the vulva. We have placed our species in *Austrofilaria* because of the presence of a marked chitinous vestibule, a bipartite oesophagus, small equal spicules, and the oesophageal position of the vulva. It differs from *A. vestibulata* in the form of the vestibule and in the length of the spicules.

Diomedenema diomedeae n. g., n. sp.

(Fig. 4-7)

A large number of these worms was found in the body cavity of a yellow-nosed albatross, *Diomedea chrysostoma*, washed ashore at Brighton, South Australia. Males up to 12 mm. long; females to 17 mm. Cuticle with minute punctations arranged in annuli and more obvious on some regions, *e.g.*, submedian line, but absent from end of tail. Anterior end compressed laterally; small rectangular mouth, dorso-ventrally elongate. Eight large papillae in two rings in submedian positions on head. Small amphids present. Vestibule 30μ long, 5μ wide from side to side, about 8-10μ dorso-ventrally; at its entrance, on each lateral wall, a strongly chitinized tricuspid tooth. Oesophageal lining strongly chitinized. Oesophagus ·6 mm. long in both sexes, part posterior to nerve ring wider. Excretory pore ·24 mm. from head end (in female); nerve ring at ·21 mm. in male.

Posterior end of male curved ventrally; anus ·1 mm. from tip of rounded tail; spicules acicular, unequal, ·21 and ·16 mm. long; one pair postanal papillae, one pair adanal, three pairs preanal.

Vulva anterior, 4·7 mm. from head end in worm 14·7 mm. long. Eggs 23μ by 58μ.

Generic diagnosis:—Relatively short filarial worms with anterior end compressed laterally; eight cephalic papillae in two rings. Mouth elongated dorso-ventrally, entrance to buccal cavity with two lateral tricuspid teeth; oesophagus not differentiated externally into two regions. Male tail short, rounded, without alae; spicules unequal. Vulva anterior, post-oesophageal. Parasites of birds. Type *Diomedenema diomedeae* n.sp.

This genus falls close to *Desmidocercella* Yorke and Maplestone. It differs in the shortness of the oesophagus, the presence of teeth in the buccal capsule, and in the absence of any spinose area on the tail.

It differs from *Austrofilaria* in the presence of buccal teeth and the position of the vulva. It shows some similarity to *Buckleyfilaria* Singh 1949, from passerine birds, in its cuticular ornamentation and in the presence of a buccal cavity; but it differs in the position of the vulva, the number of cephalic papillae and the dissimilarity of the spicules.

SERRATOSPICULUM GUTTATUM (Sch.)

This filariid is now recorded from *Falco peregrinus*, collected by A. Rau on Kangaroo Island. We had reported it previously from Moorook, South Australia

Echinonema cinctrun Linstow

Several specimens were found amongst material collected by Dr. H. Derrick from bandicoots, *Isoodon torosus,* from localities in south-eastern Queensland.

Seuratia shipleyi (Stoss.)

This species is now recorded from *Diomedea chrysostoma,* washed ashore at Brighton, South Australia. We have already recorded the parasite from other Australian albatrosses (1942, 69).

Stegophorus diomedeae (J. and M.)

This species was described by us under *Paryseria* (1942, 69) from three species of Australian albatrosses including *Diomedea chrysostoma,* the latter from Sellicks Beach, South Australia. We now record finding the same species of nematode in another yellow-nosed albatross from Brighton, South Australia. We transferred the species to *Stegophorus* (1945, 142).

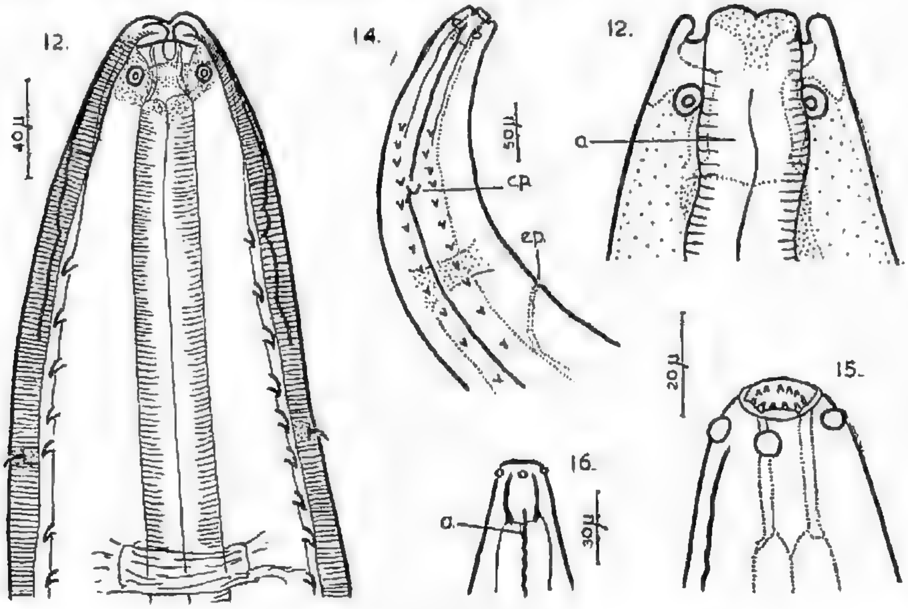

Fig. 12-16

Tetrameres australis—12, head of male, lateral view; 13, 14, anterior end of male, dorsal and lateral views respectively; 15, head of young female, sublateral view; 16, head of gravid female, lateral view. Fig. 12, 15 to same scale. a, lateral ala; cp, cervical papilla; ep, excretory pore.

Tetrameres australis J. and M.

(Fig. 12-21)

This species was originally described by us (1941) from males. The present collection, also from the black swan, *Chenopis atrata,* from Tailem Bend, South Australia, includes adult males and females, as well as young females in various stages of development.

Male—Up to 8·1 mm. in length. The original account of the head is now amended. There are four lips, typical of the genus, the dorsal and ventral being purely cuticular, whereas the laterals are wider and contain "pulp". Four large submedian papillae. The cuticular thickening of the dorsal and ventral lips is continued as a reticulum around the head as far back as the level of the base of

the buccal capsule, and laterally forms the "spines" in the lateral alae (fig. 12). These alae are broad and voluminous. Each arises from a lateral lip and has the appearance of a ribbon attached along its centre, narrowing towards the cervical papilla, behind which it is attached along one edge. Sub-lateral rows of spines commence at ·1-·13 mm. from the head end. Cervical papillae, each in the form of a single curved spine, lie at the level of the third or fourth spine, about ·16 mm. from the head end. Buccal capsule 10μ in diameter from side to side, and 15μ dorso-ventrally, its base 28-30μ from top of lips. Nerve ring at ·24 mm., and excretory pore at ·3 mm. from head end. Oesophagus 1·6 mm. long in a worm 8·1 mm. in length.

Female—Young specimens up to 4·9 mm. long, length decreasing in older worms. The most swollen females were 3·5 mm. long. Lips not distinct. Lateral alae commence just behind cephalic papillae and extend to level of vulva, are less voluminous than in male, and are not associated with spines. Cervical papillae ·15-·17 mm. from head end. Buccal cavity in young specimens cylindrical, about 25-30μ long, 7μ internal diameter; anterior margin of buccal capsule denticulate, with 10-12 projecting teeth, surrounding mouth opening. In gravid females buccal capsule becomes barrel-shaped. Oesophagus with anterior and posterior regions, ·3 and 1·1 mm. long respectively. Nerve ring at ·22 mm. and cervical papillae at ·4 mm. from head end. As the body increases in volume, the swelling of the body wall in the four submedian fields extends to include the posterior part of the oesophageal region, and most of the tail, the tip of which in the largest female is almost lost to sight. The tip of the tail in younger females is surrounded by a distinct coronet of 6-7 spines. In gravid females the tail tends to be annulated and the spines, though present, are shorter and less distinct. Vulva at 5 mm. and anus at 2·3 mm. from tip of tail, in a specimen 4 mm. long, in which the body swelling is just beginning to occur.

The species is characterised by the very long male spicule. The presence of tail spines in this genus does not seem to be a purely larval condition as it is in some Acuariids. The species does not fall into either of the subgenera proposed by Travassos in 1915, as it possesses features described as distinctive of both subgenera, *viz.*, the excessively long spicule of *Microtetrameres*, and the body spines as in *Tetrameres* s. str.

Cosmocephalus australiensis, n. sp.

(Fig. 8-11)

Several collections of a species of *Cosmocephalus* have been taken from water rats, *Hydromys chrysogaster*, from the lower River Murray, at Tailem Bend and Bow Hill, South Australia.

Females up to 12·2 mm. long; males 10·1 mm. The cordons which bound raised cuticular areas reach a point ·04 mm. from the head end, but are not as markedly convoluted as in some species of the genus. Vestibule ·1 mm. long, 9μ wide. Cervical papillae ·3-·38 mm. from head end, tricuspid in both sexes, except in one specimen where the smaller cusp was double. The foregoing measurements apply to both sexes. Citucle strongly annulate from head to cervical papillae.

Amongst the material examined were some apparently fully mature worms in which the cuticle of the anterior end was only slightly annulated. In them the position of the cervical papillae in relation to the cordon length is quite different, the cordons reaching to ·21 mm. from the head, the cervical papillae being ·5 mm. from the head. It would appear that in these forms, for some reason, possibly age or physiological differences in reaction to fixation, the cuticle and the external cuticular structures with it have not been longitudinally contracted.

Vulva in the third quarter of the body length. Eggs 40μ by 29μ. Posterior end of the male coiled into a spiral; four pairs of preanal and five pairs of postanal papillae; spicules ·57 and ·11 mm long, the shorter being broad with a blunt tip at right angle to shaft, longer acicular with a flap-like termination which may be in line with the shaft or may be bent backwardly from it (fig. 9 a).

With the adult worms are several, presumably of the same species, in various stages of development. Since none of these has a spinous tail typical of Acuariid larvae, these worms are presumably young adults. They show the growth of the cuticular appendages characteristic of the genus. The smallest is 2·5 mm. long and has a vestibule 70μ in length, *i.e.*, nearly that of the adult, while the cordons extend for only 30μ from the head end (fig. 10). In other specimens the cordons are longer; in a worm 6·3 mm. in length, the vestible is 90μ long, and the cordons extend to 90μ from the head. In the specimens with very short cordons, each cervical papilla appears as a single projection, not highly chitinized; in those with "half grown" cordons (90μ long), the cervical papillae are bifid. The shortest worm in which the papillae were trifid was a male, 7·1 mm.

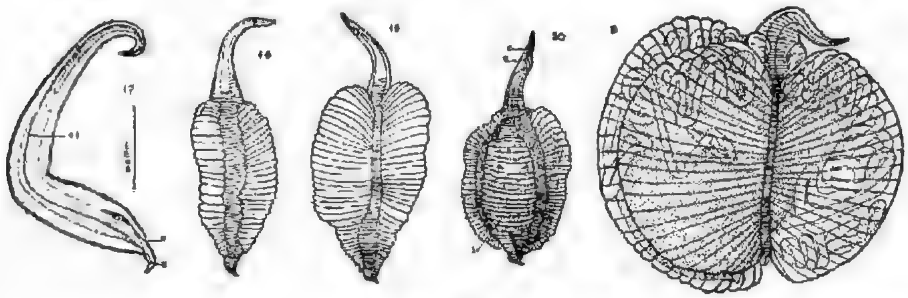

Fig. 17-21
Successive stages in growth of adult female of *Tetrameres australis*. All to same scale. a, anus; al, ala; c, cervical papilla; e, excretory pore; i, intestine; v, vulva.

in length. The shortest specimens whose sex was determinable were females. In a worm 3·8 mm. in length, the ovaries, vagina and vulva were recognisable, the vulva being situated 2·2 mm. from the head. The smallest specimen in which caudal papillae were distinguishable was 4·4 mm. long, and there were indications of incipient spicules. In all the sexually differentiated young worms the cordons were as long as, or longer than, the vestibule, and the cervical papillae were bifid, not simple. In connection with the growth of cordons and cervical papillae, one may mention the work of Chabaud (1950) on the life history of *Synhimantus spinulatus*.

We have not found any record of the occurrence of adult *Cosmocephalus* in a mammalian host, although Chandler (1942) reported *Synhimantus longigulturatus* from *Procyon lotor*, but inferred that it was an accidental infection. The food of the Australian water rat includes the yabbie (*Cherax destructor*), and various fish, either of which might harbour the larval stage of a bird parasite. We have dissected ten water rats from the Torrens and Lower Murray, and on no occasion were bird remains found in the digestive tract. This fact and the occurrence of *C. australiensis* in a flourishing condition in several water rats from different localities and at various times between 1938 and 1951 make the suggestion of an accidental infection unlikely. The only known species of the genus from Australian birds is *C. jaenschi* J. and M., from the same locality as the present specimens, but the species differ in the proportions of the lengths of the cordons and of the vestibule to each other.

Spirura (s.l.) sp.
(Fig. 22)

In several collections made from *Hydromys chrysogaster* from the lower Murray River, there occurred the posterior ends of a large species of a nematode, apparently a Spirurid. Males and females were found. In no case was an anterior end present, digestion having apparently proceeded from the head backwards in all cases. This deficiency obviated identification of the species. Measurements and a figure of the male tail are given, so that it may be possible to recognise the worm in the future.

Longest part of a female present, 23·5 mm.; of a male 7 mm., and in these an oesophagus was not present. Two ovaries and uteri are opposed; uteri unite, leading to a short vagina and vulva, the latter 6·2 mm. from the posterior end; eggs in vagina measure 40 by 28μ.

In the male are four pairs of preanal papillae and five pairs of postanal, the preanal pair nearest the anus is double-headed. Caudal alae are absent. Sicules are unequal, ·9μ and ·18 mm. respectively.

The size of the eggs and the relative lengths of the spicules in these worms and in the specimens of *Cosmocephalus australiensis* found with them, are similar; but the latter are distinctly smaller and the male tail is coiled in several spirals.

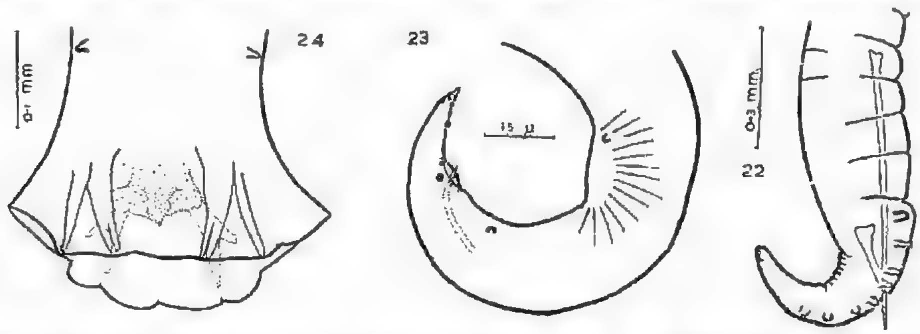

Fig. 22—*Spirura* (s.l.) sp. from *Hydromys*, male tail. Fig. 23—*Subulura peramelis*, male tail. Fig. 24—*Hypodontus macropodis*, bursa.

Contracaecum osculatum (Rud.)

This species is now recorded from the seal, *Gypsophoca tasmaniensis*. The collection included adult as well as the "phocascarid type" of immature worms described elsewhere by us (1945), and was obtained by Mr. J. McNally, from Lady Julia Percy Island, Victoria.

Stomachus sp. immature

Young forms were collected by Mr. McNally from *Gypsophoca tasmaniensis*, Lady Julia Percy Island, Victoria. In two specimens the lips had attained the adult form and the ventriculus was slightly sigmoid. The material suggests *S. similis* which occurs in elephant seals. The latter no longer occur in Australian waters, having been exterminated from Bass Strait by the early sealers.

Subulura peramelis Baylis

From bandicoots, *Isoodon torosus*, collected by Dr. H. Derrick from south-eastern Queensland. Males up to 12 mm. long; females to 17 mm. As in other collections of this species studied by us, the worms are longer than those described by Baylis, and have only three teeth in the buccal capsule.

Pharyngostrongylus alpha J. and M.

From a "white kangaroo" (*Macropus rufus,* albino), from the Koala Park, Adelaide, but previously from Mount Pleasant, South Australia; and from *Macropus major* from Narandera, New South Wales. In our original account we mentioned "six rounded inner lips," but since in specimens from *Macropus major* and in the present material, these are not obvious, it is suggested that the lip-like appearance was due to contraction of muscles surrounding the mouth.

Hypodontus macropodis Mönnig

From a kangaroo, presumably *Macropus major,* the worms having been forwarded from the McMaster Laboratory, C.S.I.R.O., Sydney. The differences between *H. macropodis* and our *II. thetidis* depend on body length, the branching of the dorsal ray of the bursa, and the length of the gubernaculum. In the present material, the dorsal ray resembles that of *M. thetidis;* but the lengths of the worm and the gubernaculum agree with *H. macropodis.* Prebursal papillae are present, as in the latter species; the position of the excretory pore is similar; and there is a backwardly-directed prolongation of the stem of the lateral ray, as noted by Mönnig (1929).

Uncinaria stenocephala Railliet

This hookworm has been identified from a fox, *Vulpes vulpes,* shot in the Adelaide Botanic Gardens.

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AUSTRALIAN RECENT AND TERTIARY MOLLUSCA (TEREBRIDAE, RISSONIDAE, FASCIOLARIIDAE, VOLUTIDAE) PLATES III AND IV

BY BERNARD C. COTTON

Summary

All Australian Recent and Tertiary species of Terebridae and Rissoinidae are reviewed. Three new species of the family Terebridae, Pervicacia subplicata, P. helenae and Nototerebra flindersi are introduced. Keys to the genera of Rissoinidae and the subgenera of Rissoina are given and the new species Rissoina vincentiana, R. grata, R. fiscina, R. jaffa and R. axiscalpta are described.

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(Terebridae, Rissoinidae, Rissoidae, Fasciolariidae, Volutidae)

Plates III and IV

By Bernard C. Cotton *

[Read 14 June 1951]

SUMMARY

All Australian Recent and Tertiary species of Terebridae and Rissoinidae are reviewed. Three new species of the family Terebridae, *Pervicacia subplicata, P. helenae* and *Nototerebra flindersi* are introduced. Keys to the genera of *Rissoinidae* and the subgenera of *Rissoina* are given and the new species *Rissoina vincentiana, R. grata, R. fiscina, R. jaffa* and *R. axiscalpta* are described.

A new genus and species of the Rissoidae is proposed and the Tertiary species of that family are listed.

Two genera of the Fasciolariidae, *Pleuroploca* and *Colus*, are considered.

To the family Volutidae is added a new species, *Ericusa orca*.

Family TEREBRIDAE

This family, some species of which possess a poison gland similar to that of the Conidae, is grouped with that family in the Toxoglossa.

Names which have been incorrectly used for Australian shells and later proved to be exotic only are:—*Terebra brevicula* Deshayes 1859 = *T. albocincta* Carpenter, Californa. *Terebra buccinulum* Deshayes 1859 = "*Bullia turrita* Gray" belonging to the family Nassidae. *Terebra fenestrata* Hinds 1843 = *Terebra caelata* Adams and Reeve 1850, China. *Terebra turrita* Smith 1873, Torres Straits = *T. textilis* Hinds 1843, Manila Bay. *Terebra polygyrata* Deshayes 1859 = *T. subtextilis* Smith 1879, Japan. *Terebra flammea* Lamarck 1822 = *T. incomparabilis* Deshayes 1859 = *Epitonium feldmanni* Bolten 1798, West Indies. *Duplicaria addita* Deshayes 1859 = *T. spectabilis* Hinds 1843, Ceylon. The large Indo-Pacific species of typical *Terebra* with characteristic colour patterns occur plentifully as species and individuals in the Damperian, Banksian, and Solanderian regions of northern Australia.

Terebra Lamarck

Terebra Lamarck 1799. Mem. Soc. Hist. Nat., Paris, 71.

Genotype—*T. subulata* Linne 1767. A synonym is *Terebrum* Montfort 1810. Species of the genus which have been recorded principally from northern Australia, most of them with a wide Indo-Pacific distribution, are *T. subulata* Linne 1767, *T. crenulata* Linne 1758, *T. dimidiata* Linne 1758 = *T. guttata* Bolten 1798, *T. oculata* Lamarck 1844, *T. muscaria* Lamarck 1822, *T. affinis* Gray 1834, *T. cancellata* Quoy and Gaimard 1822, *T. chlorata* Lamarck 1822, *T. circumcincta* Deshayes 1857, *T. columellaris* Hinds 1844, *T. exigua* Deshayes 1859, *T. jukesi* Deshayes 1857, *T. marmorata* Deshayes 1859, *T. ornatum* Martyn 1786, *T. polygyrata* Deshayes 1859, *T. straminea* Gray 1934, *T. taylori* Reeve 1860, *T. tenera* Hinds 1844, *T. turrita* Smith 1873, *T. undulata* Gray 1934, *T. hastata* Gmelin 1791, *T. bathyraphe* Smith 1875, *T. bernardi* Deshayes 1857, *T. albula* Menke 1943, *T. sublata* Linne 1758, W.A., *T. walkeri* Smith 1899 = *T. assimilis* Angas 1867, *T. lauretanae* Tenison Woods 1879, *T. tabifica* Iredale 1925.

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* South Australian Museum.

In the South Australian Museum collection *T. muscaria*, *T. bernardi*, *T. chlorata* were noted from Moreton Bay, and *T. circumcincta* from Caloundra.

PERVICACIA Iredale

Pervicacia Iredale 1924. Proc. Linn. Soc. N.S.W., **49**, 262.

Genotype—Terebra ustulata Deshayes 1857 Tasmania. Species belonging to this genus and their range are as follows.

P. ustulata Deshayes 1857. Tas. (type), N.S.W., Vict., S. Aust. The species is rare in South Australia. We have it from Pondolowie Bay, Yorke Peninsula, and some small specimens dredged in 10 fms. off Yankalilla. Pl. iii, fig. 2.

P. assecla Iredale 1924. N.S.W. (type), S. Aust., Vict. The New South Wales type was dredged in 10-25 fms. South Australian specimens were taken in 110 fms. off Beachport and 130 fms. off Cape Jaffa.

P. kieneri Deshayes 1859. N. Tas. (type), Vict., S. Aust. This is the shell originally referred to as *Terebra duplicata* var. *junior* Kiener. Kiener gave "Indian Ocean and Mauritius" for its locality. The figure is an excellent one of the South Australian species. It is the most common *Terebra* in southern Australia and can be taken in numbers in certain localities on the beach or dredged down to 22 fms. We have it from Hopetoun, King George Sound, Rottnest and Albany, Western Australia. The name *T. ustulata* Deshayes in Adcock's list of South Australian shells was intended for this shell, but as mentioned above *P. ustulata* is rare in South Australia. There is great variation in comparative attenuation and costation. Some have well-marked and subdistant ribs, others have them very crowded and fine, while others again have the former sculpture in early whorls and the latter in the later volutions. Colour varieties may be pure white throughout, or the nucleus and earlier whorls dark purple and a light purple tinge in the rest of the shell. Some of the albino variants have the ribs rather distant and valid and approach the Tasmanian shells once named *T. jukesi* later corrected to *T. bicolor*. The ribs of *T. bicolor* are more numerous than in our shell, the groove separating the infrasutural nodules from the lower part of the shell is much wider and gutter-like, and there are sublenticular inter-costular spiral striae, and the lower half of the shell is coloured too, giving a median white band. There are three principal variants.

a. Axial ribs more distant and valid, nodulose at the suture and spiral sulcus. More attenuate than average.

b. White, less solid, apex purplish in some, white in others.

c. White, narrow, solid, area beneath suture depressed. Ribs subdistant, valid. Almost like an albino form of *P. ustulata* but more attenuated than the average example of that species.

P. bicolor Angas 1867. N.S.W. (type), Vict.

Typical specimens of this do not occur in South Australia, its place apparently being taken by **P. subplicata** sp. nov. Odd specimens labelled *T. bicolor* in the Museum Collection said to come from South Australia have no definite locality.

P. fictilis Hinds 1844. N.S.W. (type), Vict.

The species, like *P. bicolor*, appears to be confined to the Peronian region. Hedley 1900 refigured and described the species and noted that *Terebra assimilis* Angas 1867 is a synonym. It differs from *P. bicolor* in being stouter, and in having broad, low axial ribs.

Pervicacia subplicata sp. nov.

(Pl. iii, fig. 3)

Shell thin, protoconch of two smooth turns, slightly mammillate, blunt; spire whorls sloping, slightly constricted just above the centre, suture distinct; aperture obliquely ovate, small; outer lip thin; columella convex thin; sculpture of adult whorls consists of obsolete irregular roundly flattened sinuous axial riblets which in the last whorl are very faintly marked below the periphery; whole surface very closely but irregularly sublenticularly jaggedly spirally incised; colour brown, light horn or lavender with dark horn coloured sinous longitudinal markings chiefly in the spaces between the axial riblets. Height 14 mm., width 3·5 mm.

Locality—Backstairs Passage 20 fms. (type). Beachport 40-150 fms. Rare on the beach.

Remarks—Holotype Reg. No. D. 10177, S. Aust. Museum.

It may be a South Australian species related to *P. bicolor* being similar in protoconch features, but the adult shell of *P. subplicata* is thinner and less validly sculptured.

Pervicacia helenae sp. nov.

(Pl. iii, fig. 1)

Shell elongate, subulate, rather solid, glossy, whorls dark-cream coloured with a narrow dark brown spiral band occupying the space between the suture and the subsutural sulcus beneath; base of the body whorl also dark brown. Sculpture of thick sinuous axial ribs, the tips cut off by a weak subsutural sulcus situated very close to the suture. Protoconch of two smooth, white glossy whorls, the first mammillate. Adult whorls eleven, the sculpture consistent from the first to last whorl. Outer lip rather thick, columella smooth, concave. Height 24 mm., diameter 11 mm.

Locality—Eyre Peninsula, Farme Beach, Coffins Bay. Holotype Reg. No. D. 14436, S. Aust. Museum.

Remarks—A series shows the shell to be consistent in characters and not variable. The holotype and other specimens presented to the South Australian Museum are adults. They differ from *P. ustulata* in being smaller, having a weak subsutural sulcus very near to the suture, convex, shorter whorls. A series of specimens was taken by Mr. J. Veitch, a West Coast collector, and forwarded for examination to the South Australian Museum by Mr. B. J. Weeding. They are named after Mr. Veitch's daughter, a keen collector.

Nototerebra Cotton

Nototerebra Cotton 1947. Rec. S. Aust. Mus., **8**, No. 4, 667.

Genotype—Terebra albida Gray 1834. Vict. *N. albida* Gray 1834. Vict. (type), S. Aust., Tas., W. Aust.

The rusty colouration is sometimes disposed as an infrasutural row of spots and at other times in oblique longitudinal markings. One individual has a depressed infrasutural band scarcely visible in the earlier whorls, but quite distinct in the later ones. The shell is not actually smooth, there are oblique sinuous accremental striae minutely crenulating the suture, and in some specimens these are gathered into groups so as to form very flat, low triangular riblets most valid just below the suture. The protoconch is of one turn and a half, slightly inflated whorls. Our specimens are from Middleton, Spencer Gulf, Port Phillip and Esperance, Western Australia.

Nototerebra flindersi sp. nov.

(Pl. iii, fig. 4)

Shell elongate, white, faintly marked with rust-like stains, protoconch of one and a half smooth, very slightly inflated whorls; adult whorls nine, narrow, very little convex, suture linear, weakly margined below by an obscure spiral impression; sculpture of sinuous, axial, irregular accremental striae. Height 25 mm., width 6 mm.

Locality—S. Aust., Beachport, 100 fms. (type) 150 fms., Cape Jaffa 130 fmts.; W. Aust., Rottnest, Ellenbrook. Holotype Reg. No. D. 14435, S. Aust. Museum.

Remarks—The species is smaller and narrower than *N. albida* and the sub-sutural depression is comparatively more marked.

Acuminia Dall.

Acuminia Dall. 1908. Nautilus, **21.** No. 11, 124-125.

Genotype—*Terebra lanceata* Linne 1788. Indo-Pacific.

Typical species of this genus have no presutural sulcus, the shell is slender and smooth, whorls flattened, earlier whorls plicated, white, with chestnut axials. Columella with one fold.

A. brazieri Angas 1871. N.S.W. (type) Vict., Tas., S. Aust. The protoconch is elongate and consists of four and a half glossy, smooth dark purplish-brown whorls. Adult whorls are sculptured with axial riblets which nodulate the margin of the suture, the axials becoming comparatively weaker in the latter part of the shell. Dredged alive in 22 fms. off Royston Head, 20 fms. off Newland Head, also 15 fms. in Investigator Straits, Backstairs Passage and Gulf St. Vincent. It is also infrequently taken dead on the beach. Tate took it in the Great Australian Bight. The whorls which are typically "obsoletely distantly plicate" may be quite validly costellate, the costellae being broadly concavely triangular in section. The spire and body whorls are sublenticularly spirally striate, the striae crossing the axial riblets. There is a rare variant sometimes taken in South Australia which has the shape of *A. brazieri* but longitudinal plications are almost as well marked as those of *Pervicacia kieneri*. This variant we have from Royston Head 22 fms., Newland Head 26 fms., Investigator Strait 14 fms., and Kangaroo Island 13 fms.

Parviterebra Pilsbry

Parviterebra Pilsbry 1904. Proc. Acad. Nat. Sci., Philad., **56,** 5.

Genotype—*Parviterebra paucivolvis* Pilsbry 1904. Japan.

The genus is distinguished by the narrow, fusiform shell, few whorls, absence of subsutural groove, long, gradually tapering body—whorl without a differentiated siphonal fasciole at the base, columella straight abruptly truncated below. The Australian species *P. brazieri* and *P. trilineata* were once placed in the genus *Euryta* H. and A. Adams 1853 (not Gestel 1848), a synonym of *Mazatlania* Dall 1900, belonging to the family Pyrenidae, where Theile also places *Parviterebra.*

P. brazieri Angas 1875. Jackson Heads, 25 fms. N.S.W. (type), Tas., Vict., S. Aust., W. Aust. Synonyms are *Euryta angasi* Tryon 1884, Rapid Head, S. Aust., a name introduced by Tryon to replace *Euryta pulchella* Adams and Angas 1863, Rapid Bay, S. Aust., "preoccupied in *Terebra* by Deshayes," *Mangelia harrisoni* Tenison Woods 1878, Clarke Island, Vict., *Olivella australis* Tenison Woods 1878, Clarks Island, Vict. Shells of the present species in the Verco Collection were identified by Sowerby from types in the British Museum of *E. pulchella* and Verco confirmed the identification on a later visit to London. He writes in M.S.S.: "The type is a dead shell and very faintly coloured."

The specimens of *E. brazieri* in the British Museum from off Port Jackson Heads are, Verco continues, "exactly the same, only more highly coloured, like the best coloured of mine." Localities of specimens in the Museum Collection are:— S. Aust., Investigator Strait 15 fms., 20 fms., Newland Head 20 fms., Pondolowie Bay, Backstairs Passage 20 fms., Porpoise Head 12 fms., Spencer Gulf; W. Aust., Hopetoun 35 fms., King George Sound 12-14 fms., Bunbury, Rottnest; N. Tas.

There is a narrow variant taken at Hopetoun 35 fms., one specimen. Beach specimens are rare, the species apparently living in deep water.

P. trilineata Adams and Angas 1863. Port Jackson, N.S.W. (type), Vict., S. Aust.

This is more slender than *P. brazieri* and the whorls are encircled with thread-like lines. We have it from South Australia, St. Francis Island, Port Lincoln, Edithburg, Backstairs Passage 17 fms., Investigator Strait.

Triphostrephanus Dall.

Triphostrephanus Dall 1908. Nautilus 22, No. 11, 124-125.

Genotype—Terebra triseriata Gray 1834. China.

Very elongate and narrow, presutural sulcus present, whorls nodulous at both margins.

T. praelonga Deshayes 1859. Q. (type), N.S.W., N.A.

A series of this species from Port Keats, north Australia, confirms the fact (Iredale 1931) that Australian shells taper less rapidly than the Chinese genotype. Our specimens suggest that *T. praelonga* does not attain to the great length of *T. triseriata*, our only shell of that species from Japan measures 135 mm. and the maximum Port Keats shell 90 mm.

Diplomeriza Dall

Diplomeriza Dall 1919. Nautilus, 33, No. 1, 32.

Genotype—Terebra duplicata Lamarck 1844. Indian Ocean.

The generic name was introduced to replace *Duplicaria* Dall 1908, preoccupied by Refinesque 1833 for a species of *Chilina*.

D. duplicata Lamarck 1844. N.W.A., N.A.

A series of living specimens from Broome, N.W.A., range in colour from pure white to dark brown. We have also a series from Darwin and Melville Island.

D. ballina Hedley 1915. N.S.W. (type), Qld.

The type came from Trial Bay, collected by C. Laseron, and Kesteven took it at Caloundra. It is not represented in the South Australian Museum Collection. Hedley compared it with *D. ustulata* Deshayes in the original description, remarking that it differed "by being more slender, and has fewer wider-spaced ribs."

D. vallesia Hedley 1912. N.S.W. (type).

The type was collected by C. Laseron at Trial Bay. This species is represented in the South Australian Museum Collection by typical specimens from that locality.

D. australis Smith 1873. S.W.A. (type), N.W.A., N.A.

So far no authentic specimens of this species have been found in the South Australian Museum Collection, but numerous juvenile specimens of *D. duplicata* from Broome and Darwin approximate to this species.

PERIRHOE Dall

Perirhoe Dall 1908. Nautilus, 22, No. 11, 125.

Genotype—Terebra circumcincta Deshayes 1857. Red Sea.

Australian species belong to the subgenus *Dimidacus* Iredale 1928 introduced for *Perirhoe melamans* Iredale 1928 for species having the spiral lines punctate as distinct from typical *Perirhoe* which has the spiral lines not punctate. Iredale 1928 pointed out that Bartsch 1923 proposed the subgenus *Terebrina*, genotype *Terebra cingulifera*, a punctate type, but this name is preoccupied by *Terebrina* Rafinesque 1815.

P. cingulifera Lamarck 1822. Described from unknown locality.

Our specimens are from Mauritius and Port Douglas, Queensland. A synonym is *Terebra pallida* Deshayes 1857. Marquesas group.

P. monile Quoy and Gaimard 1833. Marianes or Carolines (type), Qld. *P. albomarginata* Deshayes 1859. Australia (type), N.S.W. *P. exulta* Iredale 1931. N.S.W. (type). *P. melamans* Iredale 1829. N.S.W. Sydney Harbour (type). *P. pertusa* Born 1778. Qld., N.S.W., N.A. (type).

OXYMERIS Dall

Oxymeris Dall 1903. Proc. U.S. Nat. Mus., 26, 951.

Genotype—Buccinum maculatum Linne 1758. Indo-Pacific. Whorls rapidly enlarging, presutural sulcus obsolete in the adult.

O. maculata Linne 1758. We have a typical series from Melville Island, North Australia (Sayers), Murray Island (A. M. Lea) and the Barrier Reef, Queensland.

O. felinum Dillwyn 1817. Indo-Pacific; Queensland. South Australian Museum specimens are from Seychelles, Mauritius and Moreton Bay, Queensland. Formerly named *Terebra tigrina* Gmelin 1791, pre-occupied.

O. nebulosa Sowerby 1824. This species has been recorded from Queensland, but our only series is from Zanzibar.

TERENOLLA Iredale

Terenolla Iredale 1929. Mem. Qld. Mus., 9, pt. iii, 282.

Genotype—Terebra pygmaea Hinds 1843. Straits of Malacca.

This has not so far been seen in the South Australian Museum collection, but it was recorded from Michaelmas Cay, Queensland, by Iredale, 1929.

Euterebra inconspicua and *Gradaterebra scalariformis* of southern Australia and Tasmania complete the list of recent Australian species of the family.

HASTULA H. and A. Adams

Hastula H. and A. Adams 1853. Gen. Rec. Moll., 1, 225.

Genotype—Buccinum strigilatum Linne 1758. Indo-Pacific.

Shells small, slender, sculpture of regular, moderately developed axial ribs, no presutural sulcus, suture appressed.

H. strigilata Linne 1758. Queensland, North West Australia. South Australian Museum specimens are from Louis Island and Broome, West Australia, and Moreton Bay, Queensland.

H. cerithina Lamarck 1827. Timor (type); Queensland. Six specimens from Moreton Bay, Queensland.

H. hastatum Gmelin 1791. Indo-Pacific (type); Queensland. Two specimens from Moreton Bay, Queensland.

Tertiary Species

None of the Australian Tertiary species of Terebridae appear to belong to the typical genus *Terebra*. In these notes I have placed them tentatively in the genera named. The numbers following the type locality refer to the range of the species according to the Marine stage listed below.

1.	Werrikooian - - - -	Upper Pliocene
2.	Kalimnan - - - - -	Lower Pliocene
3.	Cheltenhamian - - - -	Upper Miocene
4.	Balcombian - - - -	Middle Miocene
5.	Janjukian - - - -	Lower Miocene

Pervicacia crassa Tate 1886. Aldinga, South Australia, upper beds. 2.
P. additoides Tenison Woods 1877. Table Cape, Tasmania. 5,2.
P. mutica Tate 1889. Muddy Creek, lower beds. 4.
Acuminia leptospira Tate 1888. Muddy Creek, lower beds, Victoria. 4.
A. profunda Chapman and Gabriel 1914. Mallee bore, Victoria. 2.
Nototerebra simplex Tenison Woods 1876. Table Cape. 5, 2.
N. platyspira Tate 1886. Muddy Creek, lower beds. 4.
N. angulosa Tate 1888. Murray Desert, well sinking, South Australia. 3, 2.
N. mitrellaeformis Tate 1886. Aldinga, upper beds. ?.

Triphostrephanus platyspira Tate

Triphostrephanus platyspira Tate 1886. Muddy Creek, lower beds. 4.

The species is placed in this genus because it is comparatively very elongate and has numerous (25)whorls. The sculpture is different from that of the genotype, that of *T. platyspira* being comparatively weakly developed. The protoconch is rather distinctive, large, bulbous, considerably broader than the first few shell whorls, apex reverted and immersed.

Gemmaterebra Cotton 1952

Genotype—Terebra catenifera Tate 1886. Muddy Creek, upper beds.

Shell pyramidal, whorls flattened, slightly overlapping, two spirally and axially striate; protoconch mamillate of two rather large, smooth, convex whorls.

G. catenifera Tate 1886. Muddy Creek, upper beds. 2. Pl. iii, fig. 5.
G. subcatenifera Tate 1889. Cunninghame and Jemmy's Point, Gippsland. 2.

Noditerebra Cossman

Noditerebra Cossman 1896. Pal. Comp., 2, 51.

Genotype—Terebra geniculata Tate 1886. Muddy Creek, upper beds. 2.

N. geniculata Tate 1886. Fragments of this species were noted in Adelaidean material from bores. Pl. iii, fig. 7.

Spineoterebra Sacco

Spineoterebra Sacco 1891. Moll. Piemonte Figuria, 58.

Genotype—Terebra spinulosa Doderlein. Miocene, Italy.

In this genus the shell is pupoid, subsutural sulcus absent, aperture narrow, suture appressed, columella callous, truncate anteriorly, whorls costulate.

S. subspectabilis Tate 1889. Muddy Creek, upper beds. 2, 4.
S. convexiuscula Tate 1889. Muddy Creek, upper beds. 2.

Family RISSOINIDAE

The typical *Rissoina* is axially costate and has the aperture produced below. This genus and its associates are here recognised as constituting the family Rissoinidae as distinct from the Rissoidae.

Tate 1889, Trans. Roy. Soc. S. Aust., 23, 230, reviewed the recent Rissoidae of Australia, placing the 78 species then recorded from Australian waters in the two genera *Rissoa* and *Rissoina*, "viewed in their widest acceptation." In his "*Rissoinae*" (Rissoinidae), he used nine "subgroups" which are nowadays regarded by conservative workers as sections or subgenera and by others as full genera.

In this account four genera are recognised, *Scaliola, Rissoina, Rissolina* and *Stiva*. They may be distinguished by the following key.

KEY TO GENERA

a. Operculum spiral
  b. No funicular rib on base
    c. Smooth, with agglutinated sand grains .... *Scaliola*
    cc. Sculptured .... *Rissoina*
  bb. Funicular rib on base .... *Rissolina*
aa. Operculum not spiral .... *Stiva*

SCALIOLA Adams 1860

Genotype—Scaliola bella Adams 1860. Japan.

Shell turriculate, umbilicate, thin, white, whorls smooth but covered with agglutinated grains of sand. The genus ranges from Japan to Australia and the Red Sea. It was originally described as a subgenus of *Scala*. Theile places it in the family Finellidae. From apertural features it is regarded here as belonging to the Rissoinidae.

S. bella Adams 1860. Japan (type), North Australia, Queensland.
= *S. lapillifera* Hedley 1899. Funafuti (type).
S. arenosa Adams 1862. Japan (type), North Australia, Queensland.
S. caledonica Crosse 1870. New Caledonia (type), Queensland.
S. elata Issel 1869. Red Sea (type), Queensland.

Tryon, in his Manual of Conchology, mentions two further species, *S. glareosa* and *S. gracilis* Adams from Japan.

RISSOINA Orbigny 1840

Genotype—Rissoina inca Orbigny 1840. Peru.

Shell axially costate, aperture produced below, no funicular rib. The type species is strongly axially costate throughout, the costae becoming stronger on the body whorl. Apex mammillate, aperture similunar, lip thickened and a little reflected, anteriorly effuse or faintly channelled.

Operculum corneous, thick semilunar, paucispiral, with a claviform process on the interior face. The genus is cosmopolitan in warm and temperate seas. Australian species may be arranged in subgenera. *Moerchiella, Phosinella, Zebinella, Pyramidelloides* and *Schwartziella*.

KEY TO SUBGENERA

a. Aperture with strong basal emargination
  b. No nodulose spiral ribs
    c. Axially costated .... *Moerchiella*
    cc. Reticulate
      d. Sculpture coarse .... *Phosinella*
      dd. Sculpture fine .... *Zebinella*
  bb. Nodulose spiral ribs .... *Pyramidelloides*
aa. Aperture with weak basal emargination .... *Schwartziella*

MOERCHIELLA Nevill 1880

Genotype—Rissoina gigantea Deshayes 1848. Philippines.

Shell comparatively large, thick, upper part of shells axially ribbed, lower part smooth or spirally striate. This subgenus is preferred for the Australian

species, the true *Rissoina* being very boldly axially ribbed through, including the body whorl.

Thiele 1925, inadvertently introduced *Mörchiella* to replace *Mörchia* Adams 1860, preoccupied by Albers 1850. He later, 1931, corrected this to *Mörchinella*. That genus belongs to the Adeorbidae.

R. spirata Sowerby 1825. Philippines (type). New Guinea, North Australia. A synonym is *R. montrouzieri* Souverbie 1862.

R. triangularis Watson 1886. Ascension Island (type), Queensland, North Australia.

R. variegata Angas 1867. New South Wales, Port Jackson (type); Tasmania, King Island; Victoria, Port Phillip; South Australia, St. Francis Island, Sceales Bay, Guichen Bay, Port Elliston, Macdonnell Bay; West Australia, Ellenbrook, Yallingup, Esperance, Rottnest and Hopetoun.

R. gertrudis Tenison Woods 1875. Tasmania, King Island (type); Victoria; South Australia, Guichen Bay, Macdonnell Bay, Beachport 45 fms., 110 fms., Edithburg.

Rissoina vincentiana sp. nov.

(Pl. iii, fig. 9)

Shell large, thick, cream-coloured to white with a spotted brown band below the suture; whorls seven, rather flattened, very finely spirally striate and axially plicate, the axials becoming weaker on the later whorls, obsolete on the body whorl and absent towards the middle and base; suture very narrowly channelled, aperture large, pyriform, outerlip effuse below and very thick; protoconch of two smooth whorls. Height 10 mm., width 3·5 mm.

Locality—South Australia; Gulf St. Vincent, Glenelg (type). In shell sand and generally along the southern Australian coast and dredged. Investigator Strait 15-20 fms., Port Lincoln 9 fms. West Australia: Ellenbrook, Rottnest, Yallingup, Victoria.

Remarks—Holotype, Reg. No. D14438 Sth. Aust. Museum. This Flindersian species is large, thick, and has a gradually weakening axial sculpture. It has been confused with *R. spirata* Sowerby 1824, Philippines, *R. variegata* Angas 1862, New South Wales, *R. gertrudis* Tenison Woods 1836 and *R. orbignyi* Adams 1853, Philippines and other Indo-Pacific species. It is most like *R. spirata*, which is much longer and has a marked torsion of the axis. A specimen of *R. spirata* from Milne Bay, New Guinea, measures 15 mm. in length, has ten whorls and a comparatively small protoconch.

Rissoina grata sp. nov.

(Pl. iii, fig. 6)

Shell small, narrow, solid, shining white, suture impressed, whorls round; axial ribs stout a little sinous equivalent in width to the interspaces, nine on the body whorl, nodulating the suture; aperture semilunar, lips thickened, protoconch of two smooth whorls the second fairly large and bulbous.

Height 4 mm., width 1·25 mm.

Locality—West Aust.: Ellenbrook (type), King George Sound 80 fms., 80 miles west of Eucla; S. Aust.: Cape Borda 55 fms.

Remarks—The shell is related to *R. gertrudis* Tenison Woods but it has few and strong axials. Holotype, Reg. No. D,14439, Sth. Aust. Museum.

Rissoina fiscina sp. nov.

(Pl. iii, fig. 12)

Shell small, short, solid, shining white, strongly axially ribbed, ten oblique ribs on the penultimate whorl, no spirals; whorls five, suture a little impressed, protoconch rather small and comparatively elate, of two smooth whorls the second considerably wider than the first, but narrower than the first adult whorl; aperture semilunar. Height 3·5 mm.; width 2 mm.

Locality—West Aust.: King George Sound (type), Ellenbrook, Rottnest.

Remarks—Holotype, Reg. No. D14440, Sth. Aust. Museum. This shell has less developed axials than those of *R. grata*.

PHOSINELLA Mörch 1876

Genotype—Rissoina sagraiana Orbigny. West Indies.

Shell reticulated by subequal sculpture; aperture profoundly sinuated below; operculum denticulate posteriorly.

R. hedleyi Tate 1899. Sth. Aust.: Fowler Bay (type), Backstairs Passage 17 fms., St. Francis Island, Eyre Peninsula, Cape Borda 55 fms.. West Aust.: Rottnest, King George Sound beach, Ellenbrook, Victoria.

Besides the typical form there is a variant with axial costae obsolete and more numerous spiral lirae, eight on the penultimate whorl, twenty-four on the body whorl inclusive of three small ones at the extremity of the pillar.

R. efficata Brazier 1877. Qld. (type). A synonym is *P. semisculpta* Tate 1899. Tas. (type, error).

R. clathrata Adams 1853. Philippines (type). Nth. Aust.: Torres Straits.

R. exasperata Souverbie 1866. New Caledonia (type). Funafuti, Qld., N. Aust. A synonym is *R. quasillus* Melvill.

R. horrida Garrett 1873. Viti Island, Port Curtis (type). Nth. Aust., Qld. Synonyms are *R. curtisi* Smith 1881 and *R. australis* Sowerby 1878.

R. allanae Laseron 1950. N.S.W.: Woolgoolga (type).

ZEBINELLA Mörch 1876

Genotype—Rissoina decussata Montagu. West Indies.

Shell very finely longitudinally costate and spirally striate, aperture widened and emarginate below.

Z. lintea Hedley and May 1908. Tas.: Cape Pillar 100 fms. (type); Vict.; S. Aust.: Beachport 40 fms., 47 fms., 110 fms., 150 fms., Cape Borda 55 fms., Cape Jaffa 130 fms.

All South Australian specimens have numerous distinct spiral incisions, some are colourless, some light straw-coloured and others have two brown spirals on the spire-whorls and five on the body-whorl as in *R. fausta*. A living specimen from Cape Borda 55 fms., has no colour bands but is of a uniform light greyish-brown.

R. rhyllensis Gatliff and Gabriel 1908. Vict.: Western Port (type). Verco 1908 recorded South Australian localities from Gulf St. Vincent to Beachport, 25 fms. to 150 fms., remarking that the species seems to live in about 100 fms. in South Australia and to be less frequent in the shallower and deeper water. The following localities can now be added: Spencer Gulf, Cape Jaffa 300 fms., St. Francis Island, Beachport 40 fms. and 200 fms.; West Aust.: Esperance. It is a rather variable shell. In some examples the whorls are quite flat, in others nearly all the whorl is flat, but the lower part is sharply convex, so that each

whorl is overhung by the one above it. The sutures may be linear, or slightly impressed or slightly channelled. The surface may be quite smooth and shining. There may be spiral hair-like lines and similar axial lines. These may be of about equal validity, so as to produce a microscopic latticing, or either spirals or axials may be less valid up to complete obsolescence. Colour may be absent or there may be spiral rows of brown or orange spots, only one or two on the body whorl, and one on the spire whorls, or these spots may be axial blotches extending nearly from suture to suture. *R. lintea* approximates to the channelled suture and valid spirals and *R. fausta* to the smooth and painted variety. *R. rhyllensis* has a priority of one month.

R fausta Hedley and May 1908. Tas.: Cape Pillar 100 fms. (type); Sth. Aust. Cape Borda 55 fms. and 60 fms., Beachport 110 fms., 40 fms., rare in South Australia. Those from Cape Borda are almost smooth except for fine close-set spirals and have five or six orange spirals about one-third the width of the interspaces on the body-whorl, three on the spire-whorls. Specimens from Beachport 110 fms. have five microscopic incisions and one or two orange lines or series of orange blotches; body whorl with one to five orange lines or a series of curved axial blotches. Specimens from 60 fms. off Cape Borda are smooth with a single row of orange dots or with numerous axial vermicular orange lines on the spire and body whorl.

Rissoina jaffa sp. nov.

(Pl. iii, fig. 8)

Shell attenuate, translucent, cream to yellow, whorls eight, flatly convex, sutures lightly impressed, apex rather blunt, protoconch of two smooth, shining depressed whorls; sculpture of close, fine, weak regular axial plicae crossed by even finer striae; aperture expanded effuse; columella slightly sinuous. Height 9 mm., width 2·5 mm.

Locality—Sth. Aust.: Cape Jaffa 300 fms. (type), 90 and 150 fms., Beachport 150 and 200 fms. Cape Wiles 40 miles south, 100 fms. (Hedley); West Aust.: Great Australian Bight 40 miles west of Eucla, 72 and 120 fms.

Remarks—Holotype, Reg. No. D.14441, South Australian Museum. This species is remarkable for its attenuated translucent shell and weak though regular sculpture. It is of the *R. rhyllensis* group, but axially and spirally costate. According to specimens examined from Cape Wiles, 100 fms., it is the species recorded from that locality by Hedley 1911, as *R. rhyllensis*.

Rissoina axiscalpta sp. nov.

(Pl. iii, fig. 10)

Shell elongate-ovate, apex blunt, sutures narrowly channelled, spiral lirae about twelve on the body whorl and a few on the base, axial lirae about twelve in the penultimate whorl; aperture oblique, semilunar, inner lip slightly arcuate, outer lip free, thick, with an anterior channel. Height 6 mm., width 3 mm.

Locality—Sth. Aust.: Beachport 110 fms. (type), Newland Head 24 fms., Cape Borda 62 fms., Neptunes 45 fms., Beachport 49 fms.

Remarks—Holotype, Reg. No. D14442, South Australian Museum. *R. axiscalpta* is quite distinct from any other Australian species but is somewhat like *R. iredalei* Laseron 1950, differing in the greater comparative length, flatter whorls, weaker spaced axials.

R. elegantula Angas 1880. Sth. Aust.: Aldinga Bay, beach (type), Beachport 49 to 150 fms., Cape Borda 62 fms., Yankalilla beach, Porpoise Head 17 fms., Newland Head 20 fms., Backstairs Passage 17 fms., Wallaroo 15 fms.,

Neptunes 104 fms., Cape Jaffa 130 fms., St. Francis Island 35 fms. and beach, Kingston, beach; West Aust.: Rottnest, Yallingup, King George Sound, Bunbury 15 fms.; Tas.; Vict. The species is not uncommon from the beach to 17 fms., rarer in deeper water. Although there are no longitudinal lirae of the usual type, there are microscopic striae cutting the very fine interstaces between the spiral lirae.

R. reticulata Sowerby 1824. West Indies (type), Philippines, Qld., Nth. Aust. A synonym is *R. princeps* Mörch 1876.

R. inermis Brazier 1877. Nth. Aust. (type).

R. iredalei Laseron 1950. N.S.W., Port Jackson, 15 fms. (type).

Schwartziella Nevill 1884

Genotype—*Rissoina bryerea* Montagu 1803. Cuba.

Shell with flexuous axial costae equal smooth interstaces, no spiral striae, lip with a longitudinally striate varix, rounded below, aperture without basal emargination.

R. nivea Adams 1851. Sth. Aust.: Port Lincoln (type), Eyre Peninsula, Investigator Strait 20 fms., Gulf St. Vincent, beach and dredged in shallow water, Cape Borda 55 fms., St. Francis Island 15-20 fms., and beach, Backstairs Passage 22 fms., Kingston; W. Aust.: King George Sound, beach and 12-14 fms., Bunbury 15 fms., Rottnest, Yallingup, Ellenbrook, Hopetoun; Tas.: north-west coast; Vict.

Synonyms are *R. lirata* Angas 1880, Aldinga and Holdfast Bay (type), *R. toxopleura* Tate 1893 new name for *R. lirata* Angas, not Gould 1861.

R. fasciata Adams 1853. N.S.W.: Sydney (type); Vict.; Tas.; Sth Aust.: American River, Kangaroo Island, Yankalilla, Pondolowie, Investigator Straits 15 to 20 fms., Beachport 110 fms., 49 fms., Cape Borda 55 fms., 62 fms., Robe, Kingston.

It is a shallow water species, good examples not being taken below 25 fms.; deeper water specimens are in poor condition. Synonyms are *R. flexuosa* Gould 1861, N.S.W. (type). *R. cincta* Angas 1867, N.S.W. (type). *R. hanleyi* Schwartz 1860.

R. cretacea Tenison Woods 1878, N.S.W. (type).

R. usitata Laseron 1950. N.S.W.: Clarence River, 15 fms. (type).

Pyramidelloides Nevill 1884

Genotype—Rissoina insolita Deshayes 1863. Mauritius.

Shell narrowly turretted, with spiral nodulose ribs, tuberculated below the suture, outer lip crenulately varicose, laterally compressed aperture.

R. miranda 1861. Nth. Aust.: Cape York (type).

R. nodicincta Adams 1853. Philippines (type); Qld.; Nth Aust.; New Guinea.

Rissolina Gould 1861

Genotype—Rissoina elegantissima Orbigny 1853. West Indies.

Shell with an acute elevated ridge and an adjacent constriction around the anterior extremity, sculpture of predominating axial folds.

R. angasi Pease 1872. N.S.W.: Port Jackson, deeper water (type); Vict.; Tas.; Sth. Aust.; Gulf St. Vincent, Spencer Gulf, Kangaroo Island, Robe, Middleton, Beachport 49 fms., Cape Borda 52 fms., 62 fms., Cape Jaffa 130 fms.; West Aust.; Yallingup, Esperance, King George Sound, Rottnest, Hopetoun, Ellenbrook. A synonym is *Rissoina turricula* Angas 1867, not Pease 1860.

R. crassa Angas 1871. N.S.W.: Bottle and Glass Rocks, under stones, Port Jackson (type); Vict.; Qld.; Sth. Aust: Port Sinclair, St. Francis Island, Venus Bay. Edithburg; West Aust.: Ellenbrook, Rottnest, Hopetoun, Yallingup, King George Sound 12-14 fms., and beach.

R. cardinalis Brazier 1877. Qld. (type); Nth. Aust. A synonym is *R. mercurialis* Watson 1886 Wednesday Island, Cape York, north-east Australia, 8 fms. (type).

R. teres Brazier 1877. Nth. Aust. (type).

R. inconspicua Brazier 1877. Nth. Aust. (type).

R. pulchella Brazier 1877. Nth. Aust (type); Qld. A synonym is *R. honoluluensis* Watson 1886. Honolulu (type).

R. plicata Adams 1851. Philippines (type); Qld.; Nth. Aust. Synonyms are *R. scalarina* Adams 1853, *R. turricula* Pease 1860.

R. scolopax Souverbie 1877. New Caledonia (type); Nth. Aust.; Qld.

R. kesteveni Hedley 1907. Qld.: Mast Head Reef (type).

R. obeliscus Schwartz 1860. Mauritius (type); Qld. A synonym is *R. schwartziana* Dunker, Upota (type).

R. thaumasia Melvill and Standen 1898. Madras (type); Qld.; Nth. Aust.

Stiva Hedley 1904

Genotype—Stiva ferruginea Hedley 1904. N.S.W. (type); Sth. Aust.

Shell large, solid, resembles a *Scala* in general appearance but has the typical aperture of the Rissoinidae. The operculum is peculiar, being concentric and having a hollow projecting articulating limb.

S. ferruginea Hedley 1904. N.S.W.; Woolongong 100 fms. (type). A small specimen resembling this species rather than *S. royana* was found in dredged material at Beachport, 1550 fms.

S. royana Iredale 1924. N.S.W.: Twofold Bay 10-25 fms. (type); Vict.: Gabo Island 10-15 fms.

S. nielseni Laseron 1950. N.S.W.: Crookhaven 30-35 fms. (type).

Tertiary Species

Rissoina Orbigny 1840. *Rissoa indica* Orbigny. Peru.

Subgenus *Zebinella* Mörch 1876.

R. elegantula Angas 1880. Recent. Adelaidean. Pliocene.

R. varicifera Tenison Woods 1877. Table Cape, Miocene. 2, 4.

Subgenus *Schwartziella* Nevill 1884.

R. nivea Adams 1851. Recent. Adelaidean. Pliocene.

Subgenus *Mörchiella* Neville 1884.

R. johnstoni Tennison Woods 1877. Table Cape. Miocene.

Rissolina Gould 1861. *Rissoina elegantissima* Orbigny 1853. West Indies.

R. profunda Chapman and Gabriel. 2, 3.

Family RISSOIDAE

The Recent Australian species of this family were reviewed by the author in the Trans. Roy. Soc. S. Aust., 68, (2), 1944, 286-314, pl. xvi, fig. 1-12. In the Rec. Aust. Mus., 22, No. 3, 257-287, C. F. Laseron adds a few new genera and species from New South Wales. He comments on the genus *Laevilitorina* Pfeffer here regarded as belonging to the family Littorinidae. A new species of the genus *Eusetia* Cotton 1944 is now described.

Eusetia laterna sp. nov.
(Pl.iii, fig. 11)

Shell thick, solid, pyramidal, white to slate-coloured; suture linear, aperture round, expanded; sculpture of microscopic crowded axial striae; protoconch rather depressed, of two smooth whorls. Height 3·25 mm., width 2 mm.

Locality—Beachport 200 fms. (type), also 40 fms., 150 fms., and 10 fms.; Cape Borda 55 fms.; Cape Jaffa 130 fms.; St. Francis Island 35 fms.

Remarks—Holotye, Reg. No. D.14443. S. Aust. Museum.

R. laterna is probably most like *E. columnaria* May 1910, but it is much smaller, has less swollen whorls and is of a different shape.

TERTIARY SPECIES

Tertiary species of this family are arranged as follows:—

Haurakia Iredale 1915.

H. tateana Tenison Woods 1877. Table Cape. Miocene.

H. gabrieli Chapman and Crespin 1928. Sorrento Bore, Victoria, Balcombian. 2,4,5.

H. demessa Tate and May 1900. Recent. Recorded from the Adelaidean, Pliocene.

H. novarensis Frauenfeld 1867. Recent. Recorded from the Adelaidean, Pliocene.

Linemera Finlay 1924.

L. suprasculpta May 1915. Recent. Recorded from the Adelaidean, Pliocene.

L. sculptilis May 1919. Recent. 2, 3.

Epigrus Hedley 1903.

E. chrysalidus Chapman and Gabriel 1914. Mallee bore, Victoria, Kalimnan, Pliocene.

E. cylindraceus Tenison Woods 1878. Recent. 2, 3.

Estea Iredale 1915.

E. bicolor Petterd 1884. Recorded from the Adelaidean, Pliocene.

E. kershawi Tenison Woods 1877. Recent. 2, 3, 4.

Scrobs Watson 1886.

S. gallifiana Chapman and Gabriel 1914. Mallee bore, Kalimnan, Pliocene.

Botelloides Strand 1928.

B. bassiana Hedley 1911. Recent. Mallee bore, Kalimnan, Pliocene.

Kaurenella Ludbrook 1941.

K. denotata Ludbrook 1941. Adelaidean, Pliocene.

Subestea Cotton 1944.

S. stevensiana Tenison Woods 1877. Table Cape, Miocene. 2, 4.

Eusetia Cotton 1944.

E. buliminoides Tate and May 1900. Recent, Kalimnan.

Lironoba Iredale 1915.

L. australis Tenison Woods 1877. Recent, Kalimnan.

Family FASCIOLARIIDAE

The two genera *Pleuroploca* and *Colus* are reviewed here. The remaining genera, Recent and Tertiary, are being worked out. The genotype of the typical genus is *Murex tulipa* Linne 1758 from North America. Related Australian species are placed in the genus *Pleuroploca* Fischer.

PLEUROPLOCA Fischer

Pleuroploca Fischer 1884. *Genotype—Murex trapezium* Linne 1758. Amboina. *Fasciolaria audouini* Jonas 1846, Red Sea, is said to be a synonym.

P. trapezium Linne 1758. Indo-Pacific. Two South Australian Museum specimens, D.6923, are labelled "North Queensland" and are the only records for the species in Australia to my knowledge.

P. filamentosa Bolten 1798. Indo-Pacific, Nth. Aust., Qld. We have specimens of this coral-living species from Cape York, Townsville, and Murray Island.

P. ferruginea Lamarck 1822. Australia (type). Broome. This species is narrower than *P. filamentosa*. A synonym is *Fasciolaria inermis* Jonas 1846, Red Sea.

P. altimasta Iredale 1930. Qld.: Port Curtis (type). The coastal representative of *P. filamentosa*.

P. fusiformis Valenciennes 1840. Sth. Aust.; Tas. The figure in Kiener, Coquilles Vivantes, 6, 13, pl. iv, fig. 2, published 1840, are like the shell from the South-East, South Australia. Kiener gives the locality "Nouvelle-Hollande." It is a small thick, narrow shell with the upper whorls somewhat axially ribbed, the lower whorls without axials, the outer lip well bevelled and validly spirally lirate within.

P. australasia Perry 1811. N.S.W., Vict., Tas., West Aust. Sth. Aust. This species described by Perry as "a native of New Holland and Van Diemen's Land" is one of the most common larger gastropods of South Australia and occurs all along the coast alive from low tide mark down to 55 fms. Perry's figure is unmistakable and represents a medium-sized shell with the typical large protoconch, rounded whorls with scarcely any shoulder, rather faint rounded axial ribs, colour olive-green, ribs tinted by brown spiral lirae, the aperture spirally streaked within the labrum, the columella three-plaited.

P. coronata Lamark 1822. Vict., N.S.W., Sth. Aust., Tas., West Aust. This species was described from "des iles King et des Kanguroos." It is only a variant of *P. australasia* and with the same geographical and vertical distribution. It may be sharply angled and coronated at the shoulder, but grades into the round-shouldered *P. australasia*. Both have angled and coronated early spire whorls, the adult only showing to which variant the form belongs.

P. bakeri Gatliff and Gabriel 1912. Vict. (type), N.S.W. A specimen in the South Australian Museum, D.7966, from Gabo Island, 70 fms., is typical but large, measuring 148 mm. in length. It has the strong whorls and longitudinal plications. Two specimens, D.68396, dredged off Eden, New South Wales, are atypical but probably belong to this species.

Pleuroploca eucla sp. nov.

(Pl. iv, fig. 1, 2, 3)

Shell elongate, fusiform of seven whorls excluding the protoconch of two smooth glassy, slightly pulliform whorls; spire whorls trapezoidal, with a sharp central keel, concave above, slightly convex below where they are embraced by the suture; the keel has plicate tubercles from which long, basal axial costae extend, gradually fading out at the sutures, eleven in the body and penultimate whorl; axials crossed by spiral lirae equidistant except over the base where they become more oblique and distant; aperture elongate oval, outer lip crenulate throughout, numerous close spiral striae within; columella smooth, three oblique plaits; periostracum thin, greyish; aperture and shell white.

Length 143 mm, width 55 mm.

Locality—West Aust., 60 miles west of Eucla, 72 fms. (type).

Remarks—Holotype, D.14445, Sth. Aust. Museum.

A half-grown specimen 80 mm. x 35 mm. is typical but has a comparatively larger almost bulbous protoconch, but it is undoubtedly the same species. A third

specimen, a juvenile, is 33 mm. in length and shows the typical features. The species is readily separated from *P. australasia coronata* in being more elongate, keeled, white in colour and of more delicate structure. The holotype was mentioned as a variant of *Fasciolaria australasia* by Verco 1912.

Colus Humphrey

Colus Humphrey 1797. Mus. Calonnianum, 34.

Genotype—Murex colus Linne 1758, Indo-Pacific. North Australian species besides the genotype are *C. forceps* Perry 1811, *C. nicobaricus* Lamarck 1822. From New South Wales are recorded *C. sinovellus* Iredale 1928, *C. consetti* Iredale 1928, *C. variegatus* Perry 1811 = *C. turrispictus* Martyn 1786 = *C. laticostatus* Angas 1877 = *C. genticus* Iredale 1936. From Queensland are recorded *C. boardmani* Iredale 1930, and from Western Australia *C. philippi* Jonas 1846, *C. ventricosus* Menke 1843, *C. multicarinatus* Lamarck 1822, *C. longicaudus* Lamarck 1816, N.W.A., *C. exilis* Menke 1943.

C. australis Quoy and Gaimard 1833. Sth. Aust. All along the coast from low tide down to 40 fms., and dead at 50 fms. to 150 fms. West Aust., Bunbury, Albany beach dredged down to 28 fms. King George Sound, 50 fms. to 120 fms. Great Australian Bight, west of Eucla.

The species is very common in South Australia. Verco 1895 gives *Fusus crebriliratus* Reeve 1847, *F. marmoratus* Philippi 1846, *F. rudicostatus* Sowerby 1880, *F. laevigatus* Sowerby 1880, *F. nodicinctus* Adams 1855, *F. aureus* Reeve 1847, and *F. caudatus* Quoy and Gaimard 1833 as synonyms. The protoconch is of two and a half whorls, the first two round and smooth and then half a whorl with axial bars only, ending in a simple verticle lip. From this point start abruptly the spiral lirae of the mature shell. The two smooth whorls may be swollen and in some specimens the axials cover more than a whole whorl.

Colus novaehollandiae Reeve 1848. Tas. (type), N.S.W., Vict., Sth. Aust.: Hardwicke Bay, Willunga, Glenelg, one from the beach at each locality, dredged Investigator Straits all small broken specimens in poor condition; West Aust., 90 miles west of Eucla 100 fms., four young specimens rather sharply keeled in the middle of the whorls.

Family VOLUTIDAE

The family was reviewed by the author in the Rec. S. Aust. Mus., 9, No. 2, 181-195.

The following species may now be added:—*Lyreneta laseroni* Iredale 1937, N.S.W. *Lyria deliciosa howensis* Iredale 1937, Lord Howe Island. *Lyria opposita* Iredale 1937, Mast Head Reef. *Cymbiola punctata* Swainson 1823, N.S.W. and Qld. *Ericusa sericata* Thornley 1951, Broughton Island, N.S.W., and the new species here described.

Ericusa orca sp. nov.

(Pl. iv, fig. 4, 5, 6)

Shell fusiform, elongate, rather thin, spire and body whorl comparatively narrow for the genus; polished, smooth except for fine accremental striae; whorls narrow, only slightly convex and not angled; columella with three weak plaits, outer lip a little thickened at the edge; colour cream except for a faint pink tinge towards the suture and obscure short axial pale-pink flames just below the suture; interior of aperture dark cream, suture close and simple; protoconch papillary, bluish, oblique, first whorl very small, second large, the third of the same diameter

as the second, merging into the first adult whorl, all polished and smooth except for microscopic accremental striae; first two adult whorls microscopically striate. Length 148 mm., width 58 mm.

Locality—West Aust: 90 miles west of Eucla, 100 fms.

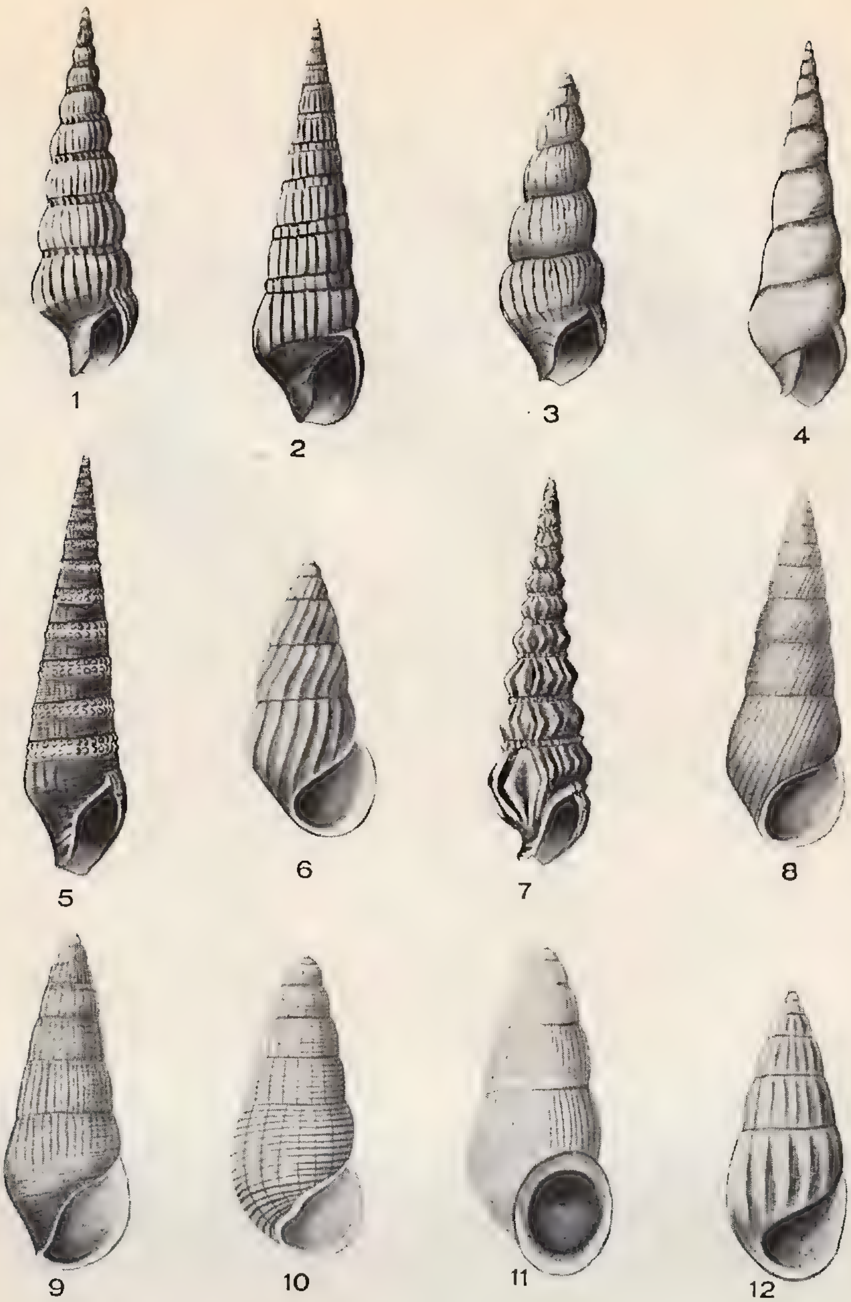
Remarks—The species is somewhat like *E. fulgetrum* Sowerby but is narrower, thinner, has less convex whorls; and the protoconch is comparatively smaller though basically similar. Holotype, D. 13816, S. Aust. Museum.

Holotype, D. 13816, S. Aust. Museum.

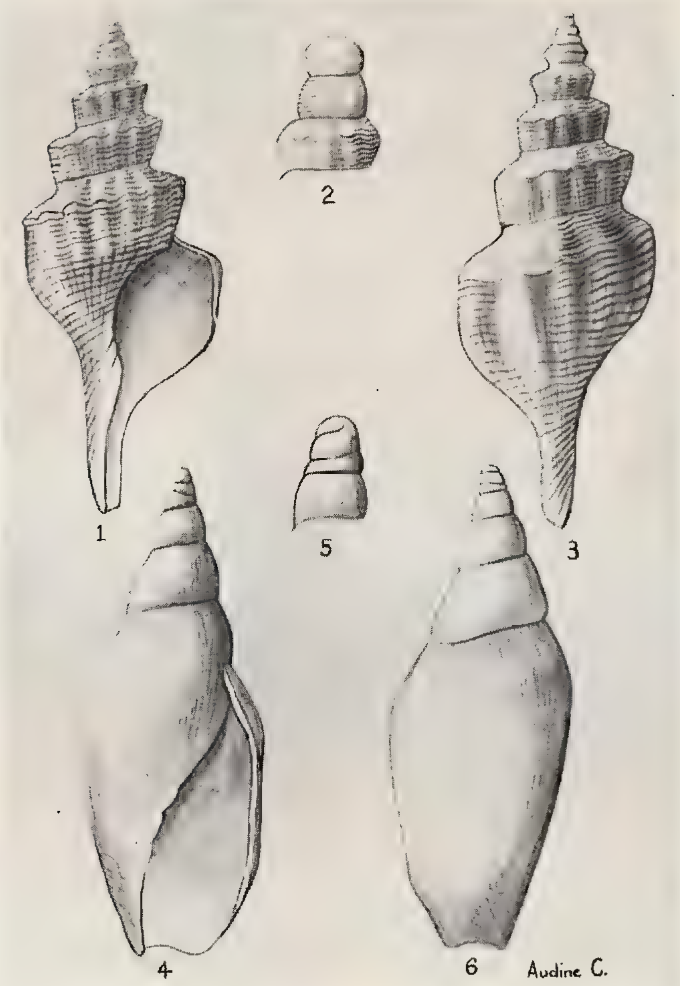
ERICUSA FULGETRUM (Sowerby)

The species occurs right along the South Australian coastline. Collectors take it alive in shallow water on sand banks. Between Coobowie and Wool Bay on the east coast of Yorke Peninsula the tides sometimes form a sand-bar which is exposed at a very low tide to the heat of the sun. When the sea begins to cover the bar, as the tide rises, these volutes and also such shells as the "False Helmet" *Hypocassis bicarinata* and "Lyre Shells" *Lyria mitraeformis* emerge from the sand. Collectors say that a dozen or more specimens have been taken in a few hours. Of the eight varieties described by Verco 1912, the figured specimen of one only is entered by him in the Museum Register, November 1915, as "D. 439 *Ericusa fulgetrum* Sby. Var. d*ictua* Verco type shell." I have not seen specimens of the *unicincta* and *bicincta* varieties.

It is not found in Victoria and the only Western Australian representative is the deeper water species described above as *E. orca.* Deeper water specimens are usually of the *dictua, lunisligata* or *connectens* varieties. *E. fulgetrum connectens* is usually quite small but a fine living specimen recently dredged by Mr. J. Veitch at Port Lincoln measures six and a quarter inches in length.



1 *Pervicacia helenae* sp. nov. x2
2 *Pervicacia ustulata* Deshayes .... x ·5
3 *Pervicacia subplicata* sp. nov. x3
4 *Nototerebra flindersi* sp. nov. x2
5 *Gemmaterebra catenifera* Tate .... x1·5
6 *Rissoina grata* sp. nov. x9
7 *Noditerebra geniculata* Tate x4
8 *Rissoina jaffa* sp. nov. x5
9 *Rissoina vincentiana* sp. nov. .... x4·3
10 *Rissoina axiscalpta* sp. nov. .... x6·6
11 *Eusetia laterna* sp. nov. x13
12 *Rissoina fiscina* sp. nov. .... x10·6



1	*Pleuroploca eucla* sp. nov., ventral	....	....	....	....	x0·4
2	*Pleuroploca eucla* sp. nov., protoconch		....	....	....	x2
3	*Pleuroploca eucla* sp. nov., dorsal	....	....	....	....	x0·4
4	*Ericusa orca* sp. nov., ventral	....	....	....	....	x0·4
5	*Ericusa orca* sp. nov., protoconch	....	....	....	....	x0·9
6	*Ericusa orca* sp. nov., dorsal	....	....	....	....	x0·4

SOME SOUTH AUSTRALIAN DESMIDS

BY GERALD W. PRESCOTT AND ARTHUR M. SCOTT (COMMUNICATED BY H. B. S. WOMERSLEY)

Summary

For the material on which the present study is based we are greatly indebted to Mr. Ivan L. Ophel of St. Peters, South Australia. With one exception, as noted, the collections were made by Mr. Ophel in 1945 and 1946, from the stations listed below:

C12. From pool, Rocky River, Flinders Chase, Kangaroo Island. Squeezed from Nitella sp. Collected by Miss C. M. Eardley, January 1940 (Tate Expedition)

C24. From pool, Breakneck River, near road, Flinders Chase, Kangaroo Island. Among Nitella sp. January 1946.

C24X. As above but slightly upstream, and squeezed from Myriophyllum sp.

C27. Pool near road bridge, Sou' West River, Kangaroo Island. Among Chara, Nitella, and Utricularia. January 1946.

C28. Pool under road bridge, Sou' West River, Kkangaroo Island. Among Nitella, Utricularia, etc. January 1946.

C30. Pool in drying-up stream, Harriet River, Vivonne Bay, Kangaroo Island. January 1946.

C33. As C30, but slightly downstream.

C39. Dam above American River inlet, Kangaroo Island. January 1946.

B42. Pool at Square Waterhole, Mount Compass Swamps. October 1945.

B50. Plankton collection from Happy Valley Reservoir, Adelaide. October 1946.

SOME SOUTH AUSTRALIAN DESMIDS

Gerald W. Prescott * and Arthur M. Scott †

(Communicated by H. B. S. Womersley)

[Read 12 July 1951]

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- C39. Dam above American River inlet, Kangaroo Island. January 1946.
- B42. Pool at Square Waterhole, Mount Compass Swamps. October 1945.
- B50. Plankton collection from Happy Valley Reservoir, Adelaide. October 1946.

Kangaroo Island, from which most of the collections were obtained, is a large island lying a few miles off the coast of South Australia, in Lat. 36° S., Long. 138° E., and therefore in the south temperate zone. The desmid-flora, therefore, might be expected to show considerable resemblance to that of the States of New South Wales, Victoria and Tasmania, which have been studied by previous workers, and our examination shows this to be the case. It differs considerably, however, from that of North Australia and the northern part of Queensland, since these are in the south tropical zone, and their desmid-flora includes many of the large and highly elaborated species that are found in the Indo-Malayan-Indonesian region.

In the following descriptions all measurements are given in microns, and these abbreviations are used: L. = length; W. = width; T. = thickness; I. = isthmus.

We wish to express our thanks to Dr. Hannah Croasdale for providing the Latin diagnoses, and to Mrs. Dorothy Perine, Jr., for inking the junior author's pencil drawings.

Where possible, references have been given to general works, which are more easily accessible than the original descriptions. In the case of new varieties the references are to the species, and for new forms the references are to descriptions of the variety.

NETRIUM

Netrium digitus var. *Naegelii* (Bréb.) Krieg. L. 92; W. 21. Breakneck River, C24X. West and West, 1904, p. 66, pl. VII, fig. 4, 5.

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CLOSTERIUM

Closterium aciculare T. West. Pl. 1, fig. 9. A needle-like species almost imperceptibly curved throughout the median two-thirds of the cell length, but more strongly toward the apices which are drawn out to fine points. L. 502-550; W. at centre; W. at poles 2. Happy Valley Reservoir, B50. West and West 1904, p. 176.

Closterium cornu Ehrbg. L. 148; W. at centre 5; W. at poles 1·5. Breakneck River, C24. West and West, 1904, p. 157, pl. XX, fig. 1-5.

Closterium cynthia De Not. fa **punctatum** fa. nov. Fig. 1, No. 3. Differing from the typical by having punctations in the wall between the striations which are relatively prominent, about 7 striae in 10 μ, and also differing in having the wall light straw-coloured rather than colourless. L. 120; W. at centre 19; W. at poles 6. Breakneck River, C24X. West and West 1904, p. 113.

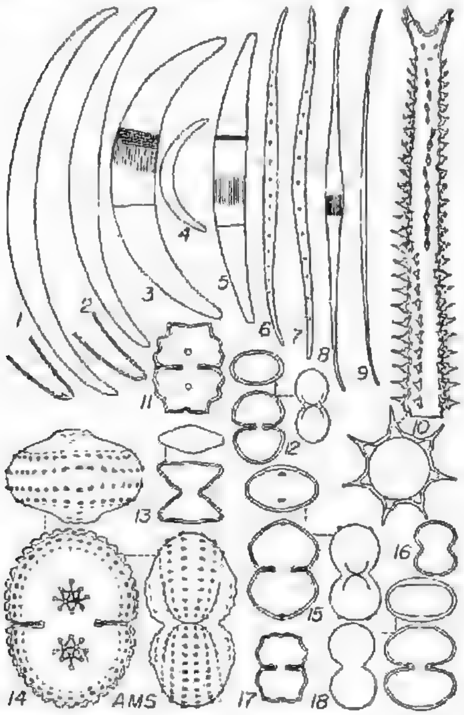


Fig. 1

1 *Closterium dianae* Ehrbg.
2 *Closterium dianae* var. *arcuatum* (Bréb.) Rab.
3 *Closterium cynthia* De Not. fa. *punctatum* fa. nov.
4 *Closterium parvulum* Naeg. var. *angustum* West and West.
5 *Closterium striolatum* Ehrb.
6, 7 *Closterium gracile* Bréb.
8 *Closterium Kuetzingii* Bréb.
9 *Closterium aciculare* T. West.
10 *Triploceras gracile* var. *bidentatum* Nordst. fa. *spinosum* fa. nov.
11 *Euastrum dubium* Naeg. var. *glabrum* var. nov.
12 *Cosmarium constrictum* Delp. fa. *minor* Fritsch and Rich.
13 *Cosmarium capitulum* var. *australe* G. S. West.
14 *Cosmarium quadrifarium* Lund. fa. *trifidum* fa. nov.
15 *Cosmarium protomphalum* Skuja var. *angulare* var. nov.
16 *Cosmarium tinctum* Ralfs.
17 *Cosmarium pseudoquadratulum* sp. nov.
18 *Cosmarium subtumidum* Nordst. var. *pachydermum* var. nov.

Forma a planta typica differens possessione punctationum in membrana inter striationes prominentes, circa 7 per 10 μ, necnon membrane pallida straminea colore potius quam sine colore. Long. 120; lat. 19; poli 6.

Closterium dianae Ehrbg. Fig. 1, No. 1. Poles obliquely truncate and bearing a granular thickening on the inner surface near the pole. L. 330; W. at centre 25; W. at poles 7. Breakneck River, C24X. West and West 1904, p. 130.

Closterium dianae var. *arcuatum* (Bréb.) Rab. Fig. 1, No. 2. A form that is more strongly curved than the typical. L. 220; W. at centre 19; W. at poles 5. Breakneck River, C24X. West and West 1904, 1, 131.

Closterium Ehrenbergii Menegh. L. 420; W. 106. Rocky River, C12. West and West 1904, p. 143, pl. XVII, fig. 1-4.

Closterium gracile Bréb. Fig. 1, Nos. 6, 7. The tapering of the apices and the curvature at the poles of the Australian plants suggest *Cl. Ralfsii* var. *novae-angliae* (Cush.) Krieg. The former are almost imperceptibly striate, or smooth-

walled, however, and have the proportions of *Cl. gracile*. L. 142-166; W. at centre 5-6; W. at poles 1·5-2. Breakneck River, C24. West and West 1904, p. 166.

Closterium Kuetzingii Bréb. Fig. 1, No. 8. Wall finely and closely striate, 22 striae visible across the cell in ours. L. 400; W. at centre 16; W. at pole 3. Breakneck River, C24. West and West 1904, p. 186.

Closterium parvulum var. *angustum* West and West. Fig. 1, No. 4. A form in which the curvature creates more of an arc than in the typical; poles strongly tapering. L. 69; W. at centre 10; W. at poles 3. Breakneck River, C24. West and West 1904, p. 134.

Closterium striolatum Ehrbg. Fig. 1, No. 5. Cells broadly convex dorsally but nearly straight along the ventral margin; striae 5-10 in 10 μ (16 striae visible in our specimens). L. 252; W. at centre 27; W. at pole 10. Mount Compass, B42. West and West 1904, p. 122.

Closterium venus Kuetz. L. 25; W. at centre 3; W. at poles 1·5. Breakneck River, C24. West and West 1904, p. 137, pl. XV. fig. 15-20.

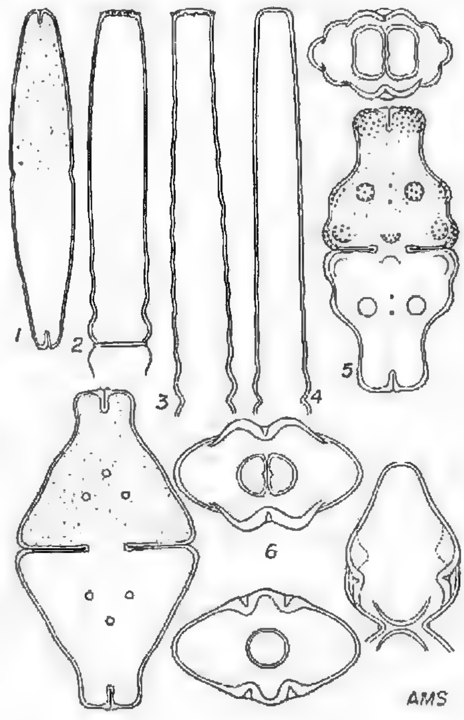


Fig. 2

1 *Tetmemorus laevis* (Kuetz.) Ralfs.
2 *Pleurotaenium coronatum* (Bréb.) Rab.
3 *Pleurotaenium Ehrenbergii* var. *undulatum* Schaarschm.
4 *Pleurotaenium trabecula* var. *rectum* (Delp) West and West, Fa.
5 *Euastrum ansatum* var. *dideltiforme* Ducell, fa. *australianum* fa. nov.
6 *Euastrum ansatum* var. *dideltiforme* Ducell.

PLEURATAENIUM

Pleurotaenium coronatum (Bréb.) Rab. Fig. 2, No. 2. L. 406; W. at base 33; W. at pole 24; I. 27. Sou' West River, C27. West and West 1904, p. 199.

Pleurotaenium Ehrenbergii var. *undulatum* Schaarschm. Fig. 6, No. 3. L. 326; W. at base 24; W. at poles 17; I. 21. Breakneck River, C24X. West and West 1904, p. 207.

Pleurotaenium trabecula var. *rectum* (Delp.) West and West. Fig. 6, No. 4. L. 302; W. at base 22; W. at poles 15; I. 18. Dam on Kangaroo Island, C39. West and West 1904, p. 209.

TRIPLOCERAS

Triploceras gracile var. *bidentatum* Nordst. fa. **spinosum** fa. nov. Fig. 5, fig. 10. A form differing in the main from the typical variety by having lateral protuberances of the wall arranged in seven or eight irregular vertical series, each protuberance furnished with a relatively long, sharp, mostly horizontally directed spine, at the base of which are two shoulders which may be elongated to form spinescences; polar lobules trispinate as in the variety. L. 414-479; W. at base including spines about 36. Breakneck River, C24X. Krieger, W. 1937, p. 444.

Forma a planta typica differens protuberationibus lateralibus membranae in 7 vel 8 seriebus verticalibus, irregulariter ordinatis, quaque protuberatione spina relative longa, acuta, plerumque horizontaliter proiciente instructa; duobus humeris spinae in basi ad spinescentiam efficiendam fortasse elongatis; lobuli polares trispinati ut in varietate. Long. 414-479; lat. in basi cemicellulae, cum spinis, circa 36.

TETMEMORUS

Tetmemorus Brebissonii Menegh. L. 286; W. at base 52; W. at pole 33; I. 30. Mount Compass, B42. West and West 1904, p. 216, pl. XXXII, fig. 1, 2.

Tetmemorus laevis (Kuetz.) Ralfs. Fig. 2, No. 1. L. 142; W. 27; I. 26. Mount Compass, B42. West and West 1904, p. 222.

EUASTRUM

Euastrum ansatum var. *dideltiforme* Ducell. Fig. 2, No. 6. The Australian plants show one of the many variations of *E. ansatum;* in this case intermediate between var. *dideltiforme* Ducell, and var. *campanulatum* (Playf.) Krieg. The facial protuberances are but slightly developed as seen in front view. L. 135-158; W. 77-79; I. 18. Mount Compass, B42. Krieger W., 1937, p. 488.

Euastrum ansatum var. *dideltiforme* Ducell. fa. **australianum** fa. nov. Fig. 2, No. 5. A form differing from the variety by having two mucilage pores, one above the other, in the mid-region of the semicell, and in having the angles and the facial protuberances deeply scrobiculate, the remainder of the cell wall finely scrobiculate or punctate. L. 90; W. 42; I. 12. Mount Compass, B42. Krieger, W., 1937, p. 488.

Forma a varietate typica differens possessione duorum pororum mucosorum, uno supra alterum, media in semicellula, et angulis atque protuberationibus profunde scrobiculatis, reliqua membrane subtiliter scrobiculata punctatave. Long. 90; lat. 42; crass. 27; isthm. 12.

Euastrum conicum (Playf.) Krieg var. **imperforatum** var. nov. Fig. 3, Nos. 1, 2. A variety differing from the typical by lacking the four mucilage pores in the mid-region of the semicell, by a complete reduction in the facial protuberances, and by its greater thickness; side view oblong with broadly convex lateral margins and a slight swelling of the basal angles. L. 118-119; W. 36; T. 28; I. 10-12. Mount Compass, B42. Playfair, G. I., 1907, p. 174.

Varietas a planta typica differens inopia quattuor pororum mucosorum media in semicellula, atque reductione completa protuberationum superficialem, atque maiore crassitudine; semicellula a latera visa oblonga, marginibus lateralibus late convexa, angulis basalibus subinflatis. Long. 118-119; lat. 36; crass. 28; isthm. 10-12.

Euastrum dubium Naeg. var. **glabrum** var. nov. Fig. 1, No. 11. Breakneck River, C24X. A variety differing from the typical by its almost complete smoothness of the cell wall, and in the shape of the semicells as seen in lateral view; semicells rectangular in face view, the lateral margins of basal lobes prominently and equally bilobed, the sinus narrow and closed throughout, one central facial tubercle

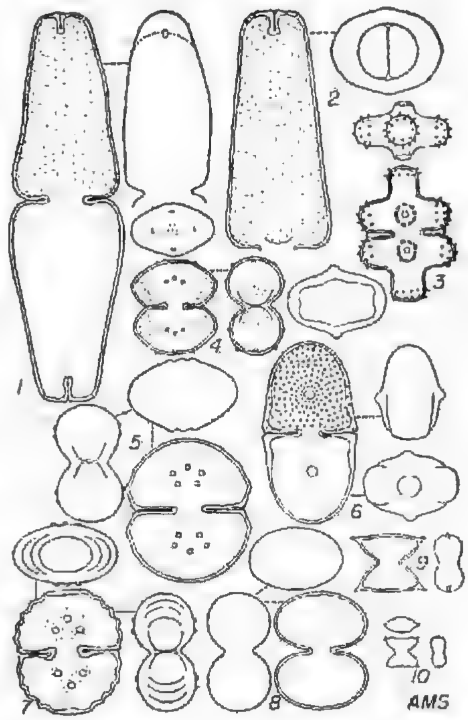
and a small tooth just within each basal angle of the semicell and slightly supra-isthmial; in lateral view semicells broadly oval, the apex rounded, with two minute teeth showing at the base of the semicell within the margin. L. 20; W. 16; T. 10; I. 4·5. Breakneck River, C24X. West and West 1905, p. 43.

Varietas a planta typica differens levitate fere tota membranae cellulae, atque forma semicellularum a latere visrum; semicellulae a facie visae rectangulares, marginibus lateralibus loborum basalium prominenter aequeque bilobatis, sinu omnino angusto inapertoque; unum tuberculum centrale facialeque et dens parvus admodum intra quemque angulum basalem semicellularum et paulum supraisthmalis; semicellulae a latere visae late ovatae, apice rotundato, duobus dentibus minutis intra marginem ad basim semicellulae. Long. 20; lat. 16; crass. 10; isthm. 4·5.

Euastrum sphyroides Nordst. Fig. 3, No. 3. L. 40; W. 30; T. 20; I. 9. Mount Compass, B42. Krieger, W. 1937, p. 625.

Fig. 3

1, 2 *Euastrum conicum* (Playf.) Krieg. var. *imperforatum* var. nov.
3 *Euastrum sphyroides* Nordst.
4 *Cosmarium rectangulare* var. *subhexagonum* Playf. fa. *granulatum* fa. nov.
5 *Cosmarium rectangulare* var. *australe* Playf. fa. *multigranulatum* fa. nov.
6 *Cosmarium rotundum* sp. nov.
7 *Cosmarium Ophelii* sp. nov.
8 *Cosmarium contractum* var. *ellipsoideum* (Elfv.) West and West.
9 *Arthrodesmus phimus* Turn. fa. *convexus*, fa. nov.
10 *Arthrodesmus phimus* var. *occidentalis* West and West fa. *minimissimus* fa. nov.



MICRASTERIAS

Micrasterias mahabuleshwarensis var. *ampullacea* (Mask.) Nordst. fa. **australiensis** fa. nov. Fig. 4, No. 4. A form differing from the typical by having a reduction in the granulations of the face of the semicell (except within the margin of the polar lobe and a row of prominent granules across the base of the semicell); lateral lobes divided into two arms, the upper of which is extended almost horizontally but somewhat arched near the body of the cell. L. 154; W. 130; I. 25. Breakneck River, C24X. Krieger, W., 1939, p. 50.

Forma a varietate typica differens reductions granulationum faciei semicellulae (nisi quod habet granula intra marginem lobi polaris atque ordinem granulorum prominentium trans basim semicellulae); lobi laterales in two brachia divisi, brachio superiore fere horizontaliter extenso, subarcuato, autem, prope corpus cellulae. Long. 154; lat. 130; isthm. 25.

Micrasterias Thomasiana var. *notata* (Nordst.) Grönbl. Fig. 4, No. 3. L. 251-255; W. 218-236; I. 29-33. Breakneck River, C24X. Krieger, W., 1939, p. 111.

COSMARIUM

Cosmarium binum Nordst L. 64; W. 45; T. 27; I. 15. Harriet River, C30. West and West 1908, p. 246, pl. LXXXVIII, fig. 10-14.

Cosmarium bioculatum Bréb. fa. L. 22; W. 21; I. 6. Breakneck River, C24. West and West 1905, p. 165, pl. LXI, fig. 3-7.

Cosmarium Blyttii Wille fa. L. 16; W. 14; I. 4·5 Sou' West River, C28. West and West 1908, p. 225, pl. LXXXVI, fig. 1-4.

Cosmarium capitulum var. *australe* G. S. West. Fig. 1, No. 13. Breakneck River, C24X. L. 20; W. 21; I. 6. West, G. S., 1909, p. 1-88.

Cosmarium constrictum fa. *minor* Fritsch and Rich. Fig. 1, No. 12. L. 17-22; W. 12-15; T. 8; I. 3. Mount Compass, B42. Fritsch, F. E., and Rich, Florence. 1924.

As Fritsch and Rich suggest, this form approaches *C. inane* Turn., with which it should be compared. Probably Turner's name is synonymous.

Cosmarium controctum var. *ellipsoideum* (Elfv.) West and West. Fig. 3, No. 8. A small form of a variety of *C. contractum*, which is a species that has much variation in size, and (as interpreted by various workers) varies in shape. Mount Compass, B42. L. 33; W. 27; T. 18; I. 8. West and West 1905.

Cosmarium cucurbitinum (Biss.) Luetkem. Fig. 4, No. 11. Wall finely punctate; wall at the poles decidedly thickened and pitted. L. 67; W. 34; I. 33. Dam on Kangaroo Island, C39. Luetkemüller, J., 1902, p. 406.

Cosmarium dentiferum Corda. Fig. 4, No. 7. L. 73; W. 71; T. 32; I. 18. Sou' West River, C27. West and West 1908, p. 156.

Cosmarium difficile var. *sublaeve* Luetkem. L. 31; W. 20; I. 4. Rocky River, C12. West and West 1908, p. 97, pl. LXXIII, fig. 4, 5

Cosmarium granatum Bréb. L. 25-27; W. 16-18; T. 8; I. 6. Breakneck River, C24, C24X. Dam on Kangaroo Island, C39. West and West 1905, p. 186, Pl. LXIII, fig. 1-3.

Cosmarium impressulum Elfv. fa. L. 15-16; W. -1213; I. 4. Breakneck River, C24X. Elfving, F., 1881, p. 13, pl. I, fig. 9.

Cosmarium margaritatum (Lund.) Roy and Biss. L. 82; W. 87; T. 42; I. 24. Dam on Kangaroo Island, C39. West and West 1912, p. 18.

Cosmarium margaritatum (Lund.) Roy and Biss. fa. **pyramidatum** fa. nov. Fig. 4, No. 6. A form differing from the typical variety by having the semicell elevated and narrowed at the poles rather than being flattened or broadly convex at the apex; lateral walls of semicells pith round granules, polar region with cone-shaped granules, all granules surrounded by a circle of deep punctations or minute pores. L. 121; W. 90; I. 30. Mount Compass, B42.

Forma a varietate typica differens semicellula elevata atque ad polos angustate potius quam complanata aut late convexa ad apicem; latera semicellularum granulis fotundatis praedita, regio polaris granulis conicis, granulis omnibus circulo punctationum profundarum aut pororum minutorum circumdatis. Long. 121; lat. 90; isthm. 30.

Cosmarium **multigranulatum** sp. nov. Fig. 4, No. 10. Cells of medium size, twice as long as wide, very slightly constricted in the mid-region to form a broad isthmus; wall densely set with transverse rows of granules (about 15 rows in each semicell); circular in end view. L. 39; W. 19; I. 17, Mount Compass, B42.

Cellulae mediocres, duplo longiores quam latae, ovatae, semicellulis elongato-ovatis, media in parte ad isthmum latum formandum paululum constrictis; membrana ordinibus transversis granulorum dense obsita (circa 15 ordinibus quaque in semicellula), cellula a vertice visa circularis. Long. 39; Crass. 19; isthm. 17.

Cosmarium multiordinatum West and West. Fig. 4, No. 8. Semicells transversely oval but with definitely truncate apices; uniformly beset with concentric rows of sharp granules; wall in the median portion of the semicell with a large circular area in which the granules are interspersed with pores which are larger and more prominent in the centre of the area, wall lightly punctate between the granules. L. 79; W. 73; T. 48; I. 23. Breakneck River, C24X. West and West 1897, p. 121.

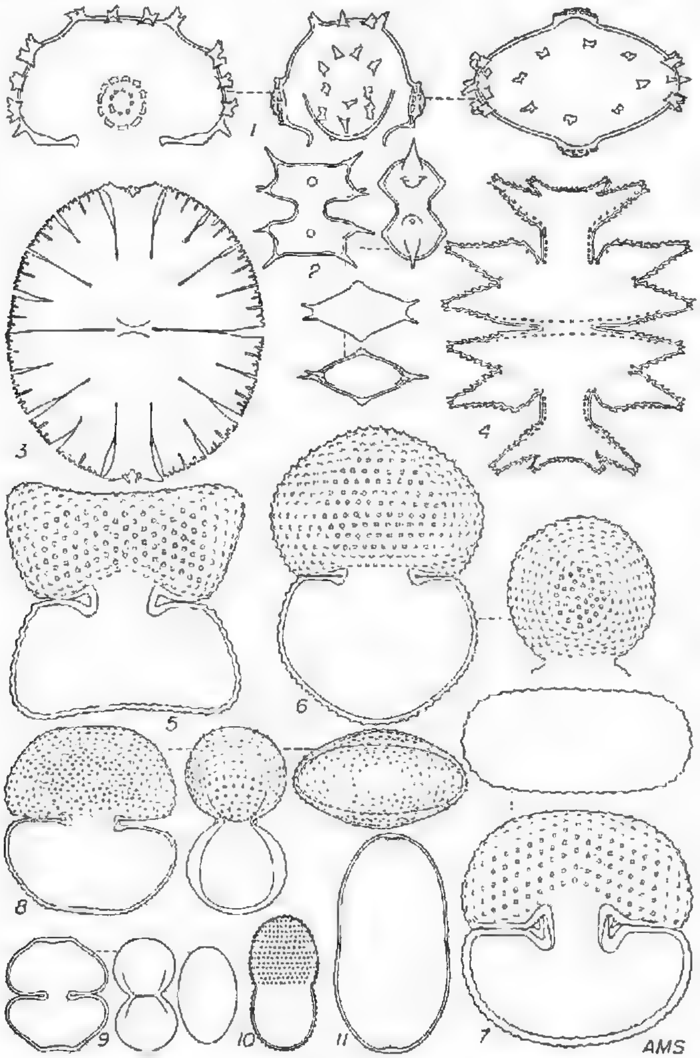


Fig. 4

1 *Xanthidium armatum* (Bréb.) Rab. var. *depressum* var. nov.
2 *Xanthidium simplicius* Nordst. var. *pseudosmithii* var. nov.
3 *Micrasterias Thomasiana* var. *notata* (Nordst.) Grönbl.
4 *Micrasterias mahabulashwarensis* var. *ampullacea* (Mask.) Nordst. fa. *australiensis* fa. nov.
5 *Cosmarium porrectum* Nordst.
6 *Cosmarium margaritatum* (Lund.) Roy and Biss. var. *pyramidatum* var. nov.
7 *Cosmarium dentiferum* Corda.
8 *Cosmarium multiordinatum* West and West.
9 *Cosmarium retusiforme* var. *major* Gutw.
10 *Cosmarium multigranulatum* sp. nov.
11. *Cosmarium cucurbitinum* (Biss.) Luetkem.

Cosmarium **Ophelii** sp. nov. Fig. 3, No. 7. Cells medium-sized, very slightly longer than wide, nearly circular in outline; semicells semicircular with flattened truncate apex which appears slightly produced because of an invagination on either side, the lateral margins with five pronounced undulations; sinus narrow and closed throughout, with a slight enlargement at the apex; wall with an irregular patch of punctations in the mid-region of the semicell where there is a triangular arrangement of three granules; side view of semicell approximately circular, with a pair of granules showing at the margin on each side in the mid-region, and a pair of granules at the base of the semicell within the margin; polar view narrowly oval with a row of three granules in the mid-region on each side. L. 37; W. 33; T. 20; I. 10. Breakneck River, C24X.

Cellulae mediocres, paulula longiores quam latae, quasi circulares; semicellulae semicirculares, apice complanato truncatoque, aspectu ob invaginationem marginis utroque in latere subproducto, lateribus 5 undulationes menifestas praebentibus; sinus angustus, omnio inapertus, ad apicem subampliatus; membrana maculam irregularem punctationum atque 3 granula in ordinatione triangulari media in semicellula habens; semicellula a latere visa propemodum circularis, pari granulorum ad marginem utrimque media in parte atque pari granulorum ad basim semicellulae intra marginem praedita; semicellula ab apice visa anguste ovata, ordine trium granulorum media in parte utroque in latere. Long 37; lat. 33; crass. 20; isthm. 10.

This species should be compared with *C. sublatereundatum* West and West, which is without granules and has a differently shaped apex.

Cosmarium Portianum Arch. L. 25; W. 18; I. 7·5. Dam on Kangaroo Island, C39. West and West 1908, p. 165, pl. LXXX, fig. 4-7.

Cosmarium porrectum Nordst. Fig. 4, No. 5. L. 97-107; W. 99-108; T. 45; I. 29-32. Breakneck River, C24X. Nordstedt, O. 1870, p. 207.

This plant should be compared with *C. quadrum* Lund. and *C. biretum* Bréb. and its varieties. The former comparison suggests the desirability of combining *C. quadrum* and *C. porrectum*. Comparison should also be made with *C. dentiferum* var. *porrectum* Playf.

Cosmarium protomphalum skuja var. **angulare** var nov. Fig. 1, No. 15. A form differing from the typical by having the lower lateral margins rather sharply diverging from the isthmus to form an angulation about midway to the apex; upper lateral margins convex and converging to the apex which is not so nearly truncate as in the typical; with a large tubercle just within the margin at the apex. L. 30; W. 22; T. 16; I. 7·5. Rocky River, C12. Skuja, H., 1937.

Varietas a planta typica differens marginibus inferioribus lateralibus ab isthmo subabrupte divergentibus ad efficiendam angulationem quasi media in parte lateris; marginibus superioribus lateralibus convexis et ad apicem minus truncatum quam in planta typica, convergentibus; tuberculum magnum admodum intra marginem in apice. Long. 30; lat. 22; crass. 16; isthm. 7·5.

Cosmarium pseudoprotuberans Kirchn. fa. L. 48; W. 37; T. 24; I. 12. Dam on Kangaroo Island, C39. West and West 1908, p. 82, pl. LXIV, fig. 6-8.

Cosmarium pseudopyramidatum Lund. fa. L. 51; W. 30; T. 21; I. 12. Rocky River, C12. West and West 1905, p. 201, pl. LXIV fig. 9-12.

Cosmarium **pseudoquadratulum** sp. nov. Fig. 5, No. 12. Cells small, 1¼ times longer than wide; semicells quadrate but with the lower lateral margins diverging from the basal angles which bear a small tubercle; upper lateral margins retuse, forming a slightly produced apex; apical margin convex but with a slight median notch (or retuseness); semicells in lateral view circular; in end view broadly oval; isthmus narrow, sinus closed. L. 15; W. 12; T. 8; I. 4. Rocky River, C12.

Cellulae parvae, 1¼ plo longiores quam latae; semicellulae quadratae, marginibus, autem, inferioribus lateralibus ab angulis qui tuberculum parvum ferunt,

divergentibus; margines superiores laterales retusi, apicem paulum productum efficientes; margo apicalis convexus, in medio, autem, subincisi (aut retusus); semicellulae a latere visae circulares; ab apice visae late ovatae; isthmus angustus, sinu inaperto. Long. 15; lat. 12; crass. 8; isthm. 4.

This species should be compared with *C. quadratulum* (Gay) De Toni, especially with its variety *applanatum* Insam and Krieger; also with *C. Regnelii* Wille. It is about the same size as the latter, but does not have a swelling in the mid-region of the semicell. The plant has a strong resemblance to *Euastrum binale* var. *hians* W. West, especially in the front view. The apex is suggestive of *Euastrum*, but the facial markings and protuberance are lacking.

Cosmarium punctulatum Bréb. L. 23; W. 21; T. 12; I. 7. Rocky River, C12. West and West 1908, p. 206, pl. LXXXIV, fig. 13, 14.

Cosmarium punctulatum var. *subpunctulatum* (Nordst.) Boerges. Fig. 5, Nos. 9, 10. L. 30-33; W. 27-30; T. 21; I. 9. Happy Valley Reservoir, B50. Breakneck River, C 24X. West and West 1908, p. 209. Our figures show two variations in pattern of granulation.

Cosmarium pachydermum fa. *transitoria* Heimerl. L. 81-88; W. 64-70; T. 39; I. 30-32. Rocky River, C12. Breakneck River, C2X. Heimerl, A., 1891, p. 596.

Cosmarium quadrifarium Lund. fa. **trifidum** fa. nov. Fig. 1, No. 14. A form differing from the typical by having the marginal verrucae conspicuously tridentate, and in having three rows of verrucae (two within the lateral margins as seen in face view); in lateral view the semicells broadly oval with a slight median protuberance on each side bearing two vertical series of granules, and with six vertical rows of granular verrucae extending from the base of the semicell to the apex. L. 51; W. 39; T. 26; I. 15. Mount Compass, B42. Lundell, P. M., 1871, p. 32.

Forma a varietate typica differens verrucis marginalibus perspicue tridentatis, et possessione 3 ordinum verrucarum (2 intra margines laterales a facie visorum); semicellulae a latere visae late ovatae, protuberatione media parva quoque in latere 2 series verticales granulorum ferentes, et 6 ordinibus verticalibus verrucarum granulosarum a basi semicellulae ad apicem extensis. Long. 51; lat. 39; crass. 26; isthm. 15.

This is probably a form of *C. quadrifarium* var. *gemmulatum* described by Maskell from New Zealand.

Cosmarium rectangulare var. *australe* Playf. fa. **multigranulatum** fa. nov. Fig. 3. No. 5. A form differing from the typical variety in having an oval pattern of five granules on the face of the semicell; in side view semicells subcircular, with a pair of granules showing on the lateral margins; polar view broadly elliptic with a row of three granules in the median part of the lateral margins. L. 41; W. 35; I. 10. Dam on Kangaroo Island, C39. Playfair, G. I., 1910, p. 480.

Forma a varietate typica differens possessione ordinationis ovate quinque granulorum in facie semicellulae; semicellulae a latere visae circulares, binis granulis in margine laterali semicellulae a polo visae ellipticae, ordine trium granulorum media in parte marginem lateralium. Long. 41; lat. 35; isthm. 10.

Cosmarium rectangulare var. *subhexagonum* Playf. fa. **granulatum** fa. nov. Fig. 3, No. 4. A form differing from the typical variety by having an arc of three granules just above the mid-region of the semicell, one granule just within the apex and one on either side of the apex (upper lateral angles); apex truncate-convex; in side view semicells circular and showing one granule at the apex and two on either side; vertical view broadly elliptic with a slight swelling having three granules in the mid-region on each side, and with a cruciform arrangement of four granules (one within each lateral margin and one within each pole); wall

at the poles of the cell and in the lower lateral angles coarsely punctate. L. 30; W. 26; T. 17; I. 7. Rocky River, C12. Playfair, C. I., 1910, p. 483.

Forma a varietate typica differens possessione arcus 3 granulorum admodum supra mediam semicellulam, granulo uno admodum intra apicem atque uno utroque in latere apicis (angulis superioribus lateralibus); apex truncato-convexus; semicellulae a latere visae circulares, unum granulum in apice, atque duo granula utroque in latere praebentes; semicellulae a vertice visae late ellipticae, mediocrem inflationem, 3 granulis media in parte utrimque instructam, habentes, et ordinationem cruciformen 4 granulorum (uno intra quemque marginem lateralem atque uno intra quemque polum) praebentes; membrana ad polos cellulae atque in angulis lateralibus grosse punctate. Long. 30; lat. 26; crass. 17; isthm. 7.

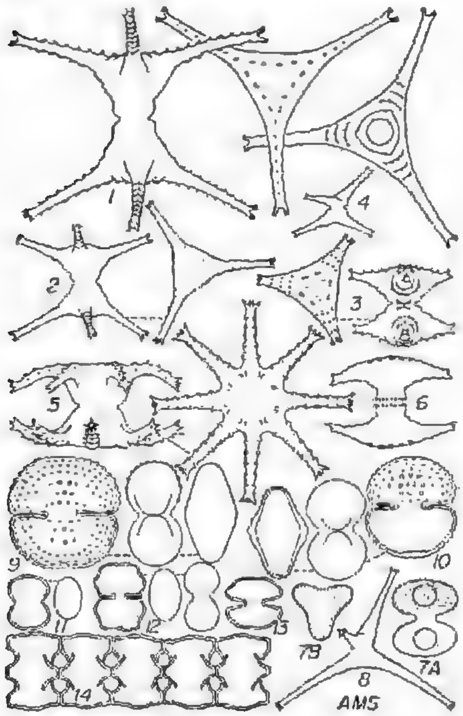


Fig. 5

1 *Staurastrum gracile* Ralfs.
2 *Staurastrum gracile* Ralfs. fa. *minimum* fa. nov.
3 *Staurastrum crenulatum* var. *continentale* Messik. fa. *mammiferum* fa. nov.
4 *Staurastrum tetracerum* (Kuetz.) Ralfs.
5 *Staurastrum sagittarium* Nordst.
6 *Staurastrum pseudosuecicum* sp. nov.
7 *Staurastrum turgescens* De Not. Fa.
8 *Staurastrum Smithii* (G. M. Smith) Teiling.
9 *Cosmarium punctulatum* var. *subpunctulatum* (Nordst.) Boerges.
10 *Cosmarium punctulatum* var. *subpunctulatum* (Nordst.) Boerges. Fa.
11 *Cosmarium tinctum* Ralfs.
12 *Cosmarium pseudoquadratulum* sp. nov.
13 *Cosmarium truncatellum* (Perty) Rab.
14 *Desmidium Baileyi* (Ralfs) Nordst. Fa.

Cosmarium retusiforme var. *major* Gutw. Fig. 4, No. 9. L. 36; W. 32; T. 18; I. 9. Breakneck River, C24X. Gutwinski, R., 1892, p. 20.

Cosmarium **rotundum** sp. nov. Fig. 3, No. 6. Cells relatively large, length about $1\frac{1}{2}$ times the width, longitudinally broadly oval in outline, the semicells semi-oval in outline, the lateral basal angles slightly thickened and out-turned, the lateral margins broadly convex to a dome-shaped apex; sinus narrow and closed throughout, the apex only slightly enlarged; wall coarsely pitted with a large tubercular protuberance in the mid-region of the semi-cell; in side view semicells broadly oval in outline with a protuberance in the mid-region on either side, a truncated lobe showing at the base of the semicell; in end view broadly oval, with a protuberance in the mid-region on each side, the poles of the figure with a truncated lobe which extends out slightly. L. 57-60; W. 30; T. 22; I. 9. Mount Compass, B42.

Cellulae maiores, longitudina circa $1\frac{1}{2}$ plo latitudine, longitudinaliter late ovatae. semicellulae semi-ovatae, angulis lateralibus basalibus subincrassatis atque extrorsus divergentibus, lateribus late convexis, apice tholiformi terminatis, sinus

angustus, omnino inapertus, apice paulum ampliato; membrana grosse lacunata, protuberatione magna tuberculari media in semicellula; semicellulae a latere visae late ovatae, protuberationem utrimque media in parte, atque lobum truncatum in basi semicellulae praebentes; semicellulae a vertice visae late ovatae, protuberatione utrimque media in parte, polis figurae lobum truncatum paulum extensum habentibus. Long. 57-60; lat. 30; crass, 22; isthm. 9.

Cosmarium sexangulare Lund. L. 39; W. 31; I. 10. Rocky River, C12. Sou' West River, C27. West and West 1908, p. 81, pl. LXXII, fig. 3.

Cosmarium subtumidum Nordst. var. **pachydermum** var. nov. Fig. 1, No. 18. A variety differing from the typical by having a more open sinus and a thickening of the wall in the mid-region of the semicell; side view of semicell transversely oval-pyramidate; end view broadly oval with the lateral margins showing thick walls. L. 27; W. 22; T. 15; I. 6. Dam on Kangaroo Island, C39. West and West 1905, p. 192.

Varietas a planta typica differens sinu magis aperto, et crassitudine membranae media in semicellula; semicellula a latere visa transverse ovato-pyramidata; a vertice visa late ovata, margine laterali membranas crassas praebente. Long. 27; lat. 22; crass. 15; isthm. 6.

Cosmarium tinctum Ralfs. Fig. 1, No. 16. Fig. 5, No. 11. A small form of the typical plant which has an open sinus and a relatively thick wall that is yellowish in colour. L. 12; W. 9; I. 6. Breakneck River, C24X. West and West 1905, p. 26.

The Australian plants agree especially with a form reported by Insam and Krieger (Hedwigia 76, pl. I, fig. 11, 12, 1936).

Cosmarium truncatellum (Perty) Rab. Fig. 5, No. 13. L. 9; W. 10; T. 5; I. 4. Breakneck River, C24X. West and West 1908, p. 72.

Cosmarium turgidum Ralfs. L. 186; W. 94; I. 82. These measurements are approximate, since only one crushed cell was seen. Mount Compass, B42. West and West 1908, p. 115, pl. LXXV, fig. 1-3.

ARTHRODESMUS

Arthrodesmus phimus Turn. fa. **convexus** fa. nov. Fig. 3, No. 9. A form differing from the typical by having a broadly convex apex, upper lateral angles ending in a short, stout spine which is almost horizontally extended (or slightly upward). L. 12-14; W. 14-17; T. 8; I. 6. Breakneck River, C24. West and West 1912, p. 104.

Forma a planta typica differens apice late convexo, angulis superioribus lateralibusque spina brevi crassaque, fere horizontaliter (aut paulum sursum) extansa terminatis. Long. 12-14; lat. 14-17; crass. 8; isthm. 6.

Arthrodesmus phimus var. *occidentalis* West and West fa. **minimissimus** fa. nov. Fig. 3, No. 10. A minute form in which the semicells are slightly more stout, and which are broadly oval in outline rather than narrowly elliptic as in the variety. L. 5; W. 5; I. 2·5. Breakneck River, C24, C24X. West and West 1912, p. 104.

Forma minuta, semicellulis paululo crassioribus et late ovatis potius quam anguste ellipticis ut in varietate. Long. 5; lat. 5; isthm. 2·5.

XANTHIDIUM

Xanthidium armatum (Bréb.) Rab. var. **depressum** var. nov. Fig. 4, No. 1. Semicells relatively somewhat wider than in the typical, furnished with three irregularly dentate verrucae just within each lateral margin and a stout deflected spine near the basal angles; sinus narrow and more nearly closed than in the

typical; face of semicell with a double circle of granules; in side view semicell broadly oval, four verrucae showing at the apex and an oval pattern of eight verrucae in the mid-region enclosing a pair of spines; lateral margin in side view with a prominent tubercular thickening showing a double row of granules, a pair of tubercles showing at the base of the semicell in the mid-region. L. without arms 104, with arms 114; W. without arms 89, with arms 97; T. 67; I about 34. Mount Compass, B42. West and West 1912, p. 51.

Semicellulae relative latiores quam in planta typica, tribus verrucis irregulariter dentatis admodum intra quemque marginem lateralem, atque spina crassa deflexa prope angulos basales praeditae; sinus angustus, magis inapertus quam in specie; facies semicellulae duos circulos granulorum habens; semicellula a latere visa late ovata, praebens 4 verrucas ad apicem, at que media in parte ordinationem ovatam 8 verrucarum par spinarum includentem; margo lateralis a latere visus habens incrassationem tubercularem prominentem duos circulos granulorum praebentem, pari tuberculorum ad basim semicellulae media in parte. Long. sine brachiis 104, cum brachiis 114; lat. sine brachiis 89, cum brachiis 98; crass. 67; isthm. circa 34.

Xanthidium simplicius Nordst. var. **pseudosmithii** var. nov. Fig. 4, No. 2. A variety with a prominent facial protuberance in the mid-region of the semicell; upper lateral angles furnished with a single stout spine; two spines at the lower lateral angles of the semicell; sinus widely open, the apex broadly convex; in side view semicells broadly oval to nearly circular with a decided thickening and protuberance in the mid-region on each side, the pole furnished with a long stout spine, with one or two smaller spines in the centre of the figure (base of semicell). L. without spines 27, with spines 37; W. without spines 27, with spines 39; T. 18; I. 9. Mount Compass, B42. Nordstedt, O., 1888, p. 44.

Varietas protuberationem facialem prominentem media in parte semicellulae praebens; angulis superioribus lateralibus semicellulae spine unica crassa praeditis; angulis inferioribus lateralibus duobus spinis praeditis; sinus late apertus, apice late convexo; semicellulae a latere visae late ovatae ad fere circulares, incrassatione at que protuberatione perspicua media in parte utrimque praeditae; spinam longam crassamque ad polum atque 1 vel 2 spinas minores media in figura (ad basim semicellulae) praebentes. Long. sine spinis 27, cum spinis 37; lat. sine spinis 27, cum spinis 39; crass. 18; isthm. 9.

This variety should be compared with both *X. simplicius* and *X. Smithii*. It is more like the former than the latter, but indicates that these two species might be combined.

STAURASTRUM

Staurastrum connatum (Lund.) Roy and Biss. fa. L. 42; W. with spines 48; I. 12. Mount Compass, B42. West and West 1923, p. 15, pl. CXXX, fig. 6-8.

Staurastrum crenulatum var. *continentale* Messik. fa. **mammiferum** fa. nov. Fig. 5, No. 3. A form differing from the typical variety by having a spine-tipped mammilla on each side at the base of the semicell, producing a slightly narrower sinus; vertical view triangular with a triangular pattern of paired granules at the crown and transverse rows of granules on the arms. L. 23; W. 30; I. 6. Happy Valley Reservoir, B50. Messikommer, E., 1927, p. 107.

Forma a planta typica differens possessione mammillae spina minutae utroque in latere ad basim semicellulae, sinum paululo angustiorem efficientis; cellula a vertice visa triangularis, ordinationem triangularem granulorum binorum ad coronam necnon ordines transversos granulorum, in brachiis habens. Long. 23; lat. 30; isthm. 6.

Staurastrum gracile Ralfs. Fig. 5, No. 1. L. without processes 42-45; with processes 51-61; W. with processes 77-80; I. 9-10. Abundant in the plankton of Happy Valley Reservoir, B50. West and West 1923, p. 96.

This is a form of an extremely variable species (which has been confused with other species by various authors) that is smooth at the base of the semicell rather than bearing granules as do many of the other expressions of *St. gracile*.

Staurastrum gracile Ralfs fa. **minimum** fa nov. Fig. 5, No. 2. A form similar in shape and proportions to the typical, but with a reduction in granulation, and smaller in size; end view showing minute granulations arranged in pairs and forming a triangle about the crown, and with the surface of the arms bearing minute granules (solitary near the distal end of the arm, transversely in twos or threes approaching the body of the cell). L. without processes 24, with processes 34; W. with processes 44; I. 9. Plentiful in the plankton of Happy Valley Reservoir, B50, together with the specific form.

Forma conformatione proportionibusque plantae typicae similis, reductionem, autem granulationis habens et minor; semicellula a vertice visa binas granulationes minutas, et circum coronam triangulam efficientes, praebens, necnon in superficie brachiorum granulationes minutae (singulae ad extremitatem distalem brachii, transverse binae ternaeve ad corpus cellulae). Long. sine processibus 24, cum processibus 34; lat. cum processibus 44; isthm. 9.

This should be compared with *St. pingue* Teiling which it closely resembles, but which is smaller and differently shaped at the base of the semicells.

Staurastrum mucronatum Ralfs, fa. L. 21; W. with spines 24; I. 5. Rocky River, C12. West and West 1923, p. 11, pl. CXXX, fig. 10-12.

Staurastrum muticum Bréb. L. 21; W. 21; I. 6. Breakneck River, C24. West and West 1912, p. 179, pl. CXVIII, fig. 16-20.

Staurastrum **pseudosuecicum** sp. nov. Fig. 5, No. 6. A medium-sized species, width slightly greater than the length, slightly campanulate at the base, and extended into approximately horizontally projecting arms, which are trispinate at the tip; a circle of granules at the base of the semicell just above the isthmus which is relatively wide; apex broadly convex bearing a marginal row of five bidentate verrucae; vertical view fusiform, the lateral margin broadly convex in the mid-region and showing an oval pattern of paired granules at the crown (medianly in the figure). L. 28; W. with processes 33-50; T. 13; I. 7. Breakneck River, C24, C24X.

Species mediocris, latitudine paululo maiore quam longitudine; semicellulae biradiatae, ad basim paulum campanulatae, et in brachia fere horizontaliter projecta, ad cacumen trispinata, extensae; circulus granulorum ad basim semicellulae admodum supra isthmum latiorum; apex late convexus, ordinem marginalem 5 verrucarum bidentatarum ferens; cellula a vertice visa fusiformis, margine laterali late convexo media in parte et ordinationem ovatum granulorum binorum ad coronam (figurae media in parte) ferens. Long. 28; lat. cum brachiis 35-50; crass. 13; isthm. 7.

Our plants are questionably assigned a new name pending the appearance of additional material for examination. It is unlike other biradiate species.

Staurastrum punctulatum Bréb. fa. L. 30; W. 24; I. 8. Rocky River, C12 West and West 1912, p. 179, pl. CXXVII, fig. 8-11.

Staurastrum sagittarium Nordst. Fig. 5, No. 5. In vertical view either 8- or 9-radiate. L. 27; W. without processes 57; I. 13. Rocky River, C12. Breakneck River, C24X. Nordstedt, O., 1888, p 37.

Staurastrum Smithii Teiling (Syn.: *St. contortum* G. M. Smith). Fig. 5, No. 8. L. without processes 12, with processes 45; W. with processes 54; I. 6. Happy Valley Reservoir, B50. Smith, G. M., 1924, p. 98.

Staurastrum tetracerum (Kuetz.) Ralfs. Fig. 5, No. 4. L. 20; W. 24; I. 4·5. Sou' West River, C28. West and West 1923, p. 118.

Staurastrum turgescens De Not. fa. Fig. 5, No. 7. L. 22; W. 18; I. 6. Breakneck River, C24X. West and West 1912, p. 167.

HYALOTHECA

Hyalotheca dissiliens (Smith) Bréb. L. 16-17; W. 26-27. Mount Compass, B42. West and West 1923, p. 229, pl. CLXI, fig. 16-27.

SPHAEROZOSMA

Sphaerozosma excavatum Ralfs. L. 9; W. 9; I. 4·5 Breakneck River, C24X. West and West 1923, p. 211, pl. CLX, fig. 1-3.

DESMIDIUM

Desmidium Baileyi (Ralfs) Nordst. fa. Fig. 5, No. 14. L. 16; W. max. 24. Sou' West River, C27, C28.

With its irregular and somewhat inflated lateral margins, the Australian plant differs somewhat from the European and American forms.

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A NEW APPROACH TO THE PROBLEM OF HUMAN EVOLUTION

BY A. A. ABBIE

Summary

The paper presents a brief survey of some of the best known human and near-human fossils to set out the difficulties they present in interpretation. A review of archaeological finds indicates that cultural attainments cannot be equated with physical or menatal attainments and are no index of evolutionary development. The morphological characters of ancient physical types, particularly Neanderthal Man, are analyzed and shown to lie within the range of human variation. It is considered that the only distinguishing human feature is absolute and relative brain size, and that all the fossils considered, with the exception of Australopithecinae, are simply variants of the normal human pattern. It is considered, further, that the present method of trying to trace human evolution by comparison of adult forms is futile. The only common stem that can be found for the primates lies in an early embryonic series. In this series a sufficiently generalized precursor for man could be produced by practically any of the primates. Consequently, it is unnecessary to go very far back into primate history to find the ancestral form.

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By A. A. Abbie *

[Read 11 Oct. 1951]

SUMMARY

The paper presents a brief survey of some of the best known human and near-human fossils to set out the difficulties they present in interpretation. A review of archaeological finds indicates that cultural attainments cannot be equated with physical or mental attainments and are no index of evolutionary development. The morphological characters of ancient physical types, particularly Neanderthal Man, are analyzed and shown to lie within the normal range of human variation. It is considered that the only distinguishing human feature is absolute and relative brain size, and that all the fossils considered, with the exception of the *Australopithecinae,* are simply variants of the normal human pattern. It is considered, further, that the present method of trying to trace human evolution by comparison of adult forms is futile. The only common stem that can be found for the primates lies in an early embryonic series. In this series a sufficiently generalized precursor for man could be produced by practically any of the primates. Consequently, it is unnecessary to go very far back into primate history to find the ancestral form.

INTRODUCTION

While the fact of human evolution is not in doubt there is still great uncertainty over the course which it has followed. Most writers agree that man's origin is associated with the primates, but which—if any—represents the directly ancestral form and who are his nearest relations today are still the subject of controversy. Wood Jones (1929) finds the common ancestry in shrews, Le Gros Clark (1949) traces an evolutionary sequence which starts with the shrews and passes ultimately through the Miocene apes and the *Australopithecinae.* Gregory (1934) postulates a common lemuroid ancestry for all modern higher primates and relates man closely to the great apes. There are many other possible schemes. The problem is to discover a primate sufficiently like man to be acceptable as a close relation, yet sufficiently generalized to qualify as a possible ancestor. The only satisfactory candidate so far discovered is man himself.

A further major problem is man's relatively late appearance on earth. His one million years or so is a small fraction of the 40 million years allotted to monkeys and apes or the 60 million for lemurs. On the traditional view the factors which went into making these animals must be associated with those which went into the making of man. Yet, despite considerable search, this great interval of time is not even within sight of being bridged.

The purpose of this paper is to show how much our thinking on human evolution has been constrained by a too naive conception of the Darwinian theory. It is felt that when this restrictive outlook is replaced by a broader biological approach many of the difficulties in the interpretation of human fossils will diminish or vanish altogether. In particular, it is hoped to show that a generalized human ancestor is not necessarily so remote as it sometimes seems to be.

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PREHISTORIC REMAINS

Anatomical Evidence

Here attention is directed almost entirely to a few of the most difficult of human or near-human fossils. Man is the only positive fact in human evolution, and all hypotheses involving other primates must remain suspect so long as the relationship of those primates to man is itself in doubt. However, reference to other primates is included in later consideration of the problem.

Australopithecinae—These were first described by Dart (1925) from the Taungs skull. Few anthropologists endorsed Dart's claim for human affinities for this skull (see Keith, 1929) and it languished until the discovery of similar material at Sterkfontein and Kroomdrai (Dart, 1940; Broom, 1946). In these creatures the skull has many anthropoid characters, including protuberant jaws, an exposed premaxillary suture and a brain within the anthropoid range (Schepers, 1946). On the other hand, the teeth are more human (Dart, 1925; Keith, 1929; Gregory and Hellman, 1939; Le Gros Clark, 1950 a) and the forward site of the foramen magnum suggests an upright posture. The claim for an upright posture has been sustained by the hip bone, which is strikingly humanoid (Dart, 1949; Le Gros Clark, 1950 b). The Taungs skull is rather doubtfully referred to the late Pliocene or lower Pleistocene, the Kroomdrai remains to the middle Pleistocene (Dart, 1940).

Pithecanthropinae—The discovery of *Pithecanthropus* by Dubois in 1891-2 (see Dubois, 1896) seemed to provide the anticipated intermediate form between ape and man, combining a simian type of calvaria with a human type of femur. Indeed, the mixture proved too strong for some to stomach and they postulated a more or less fortuitous association of human and ape remains. Later discoveries by von Koenigswald (see Weidenreich, 1945 a), however, confirmed the original pronouncement and disclosed that the situation of the foramen magnum is consistent with an upright posture. *Sinanthropus*, discovered much later (Black, 1934) does not differ significantly from Pithecanthropus (Weidenreich, 1940 a; Le Gros Clark, 1945). Both have been assigned to a period between lower and middle Pleistocene in age.

Neanderthal Man—Until the discovery of Pithecanthropus Neanderthal Man provided the nearest approach to the expectations of evolutionists. His low brow, heavy eyebrow and occipital ridges, backwardly-displaced foramen magnum, prominent jaws and small mastoid process, together with a femur and calcaneum which betokened a shambling gait, all fitted into the picture so nicely. In 1864 King named the creature *Homo neanderthalensis* and Schwalbe and others assigned him to an entirely distinct human species. Neanderthal Man proper belongs to the lower part of upper Pleistocene horizons.

Piltdown Man—This skull, too, presents a curious *mélange* of simian and human features. The most recent reconstructions (Elliot Smith, 1927; Keith, 1929, 1938) indicate a modern type of cranium with a good mastoid process but no great development of supraorbital and occipital ridges. On the other hand, the teeth posses simian characters and the mandible betrays some evidence of a "simian shelf". The usual controversy over whether or not the remains all belonged to the same individual has been virtually disposed of by the fluorine method (Oakley, 1950). Oakley puts this fossil between middle and upper Pleistocene.

While each of these groups might be considered a step in the evolutionary advance towards modern man, each presents points of difficulty. Ignoring the possibility of chronological overlap, *Australopithecus* and *Pithecanthropus* could conceivably represent successive stages, but Neanderthal Man—their

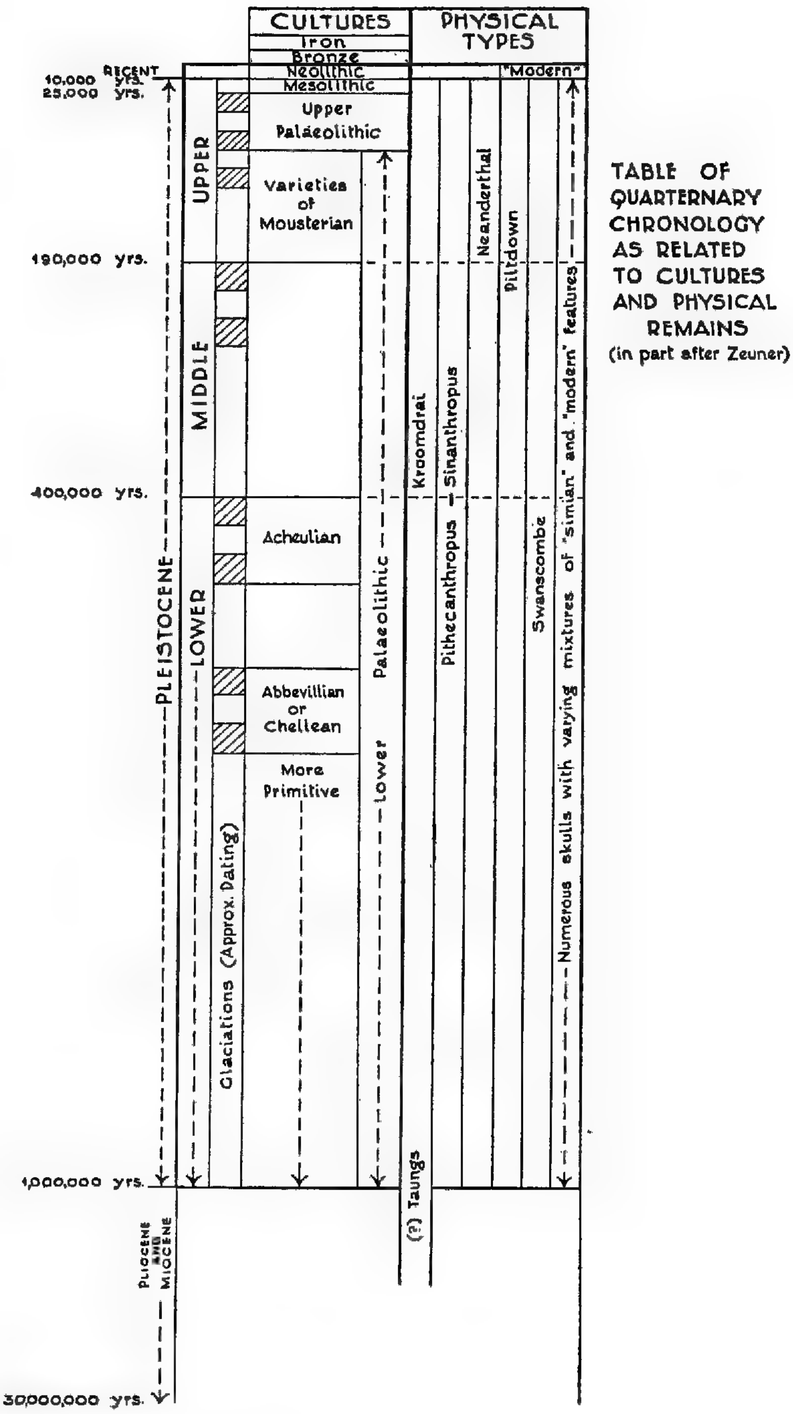

Fig. 1
Simplified outline of Quaternary chronology.

heir presumptive—is considered not to have had an erect posture and so is disqualified from inclusion in a series between erect *Pithecanthropus* and erect modern man; also, he occurred too late, overlapping ancient examples of modern man (fig. 1). Piltdown Man, too, mixes simian and human characters, but he also occurred too late to be considered ancestral to modern man. In fact, practically every hominoid fossil presents some physical or chronological discrepancy, and it is little wonder that many anthropologists have despairingly assigned them all to specialized offshoots from some common generalized stem which has progressed undeviatingly up to modern man.

That common stem unfortunately remains purely hypothetical, for it has not produced a single convincing example. Nevertheless, it seems likely that there is a common stem and a suggestion is presented later. But in this conception the representatives of the stem appear altogether different from those usually visualized by evolutionists.

Archaeological Evidence

For Europe, workers have now established a fairly clear and orderly sequence of stone implement evolution (e.g., Peyrony, 1927; Capitain, 1931; and others), often referable to specific geological horizons (see Zeuner, 1950). In many instances, however, cultures overlap, intermingle or seem displaced from the accepted chronological order, and the problems posed by these nonconformities are far from being solved.

In only a few cases have distinctive cultures been decisively associated with human remains (fig. 1). The Swanscombe skull may now be assigned with fair confidence to a lower Pleistocene horizon containing Acheulian implements (Oakley, 1938, 1950). Neanderthal remains are referred to the Mousterian cultures of the early upper Pleistocene. But from the end of the lower Palaeolithic all cultures are associated with human remains indistinguisable from those of modern man. Since the Swanscombe skull is also indistinguishable from that of modern man (Le Gros Clark, 1938; Morant, 1938) the sole problem of physical anthropology in Europe at present centres around Neanderthal Man. Indeed, Neanderthal Man has so hypnotized anthropologists that—as Keith (1929) and Leakey (1950) have complained—modern-type skulls found in ancient strata are often automatically dismissed as intrusions. In fact, European anthropology might almost be described as "Neanderthalology," for no findings outside the Neanderthal offer any serious difficulty.

Despite the accumulation of much detailed information, the positive contribution to our knowledge of man in Pleistocene times is very meagre. This information relates mainly to central and western Europe, with some extensions to Africa and the Near East. Even in western Europe the geological-archaeological association is not always conformable to the accepted plan, while in eastern Europe the correlation begins definitely to fail (Zeuner, 1950). Consequently, as Zeuner has emphasized, there is little present justification for extending to more distant parts of the world—e.g., eastern Asia or Australia—a chronology based upon the geological succession in a relatively restricted region. Similar geological formations elsewhere are not necessarily contemporaneous.

There is an unfortunate tendency to confuse geology, achaeology and physical anthropology, and to describe one in terms of the other. Thus, a geological horizon may be referred to as "Acheulian" or "Aurignacian". Much worse is the confusion of physical characters with cultural findings. Such terms as "Chellean Man" or "Levalloisian Man" are commonly employed, with the implicit assumption of a distinct physical type to be associated with the artifacts he left behind. Even Zeuner (1950, p. 164) sins

here when he tries to fit cultural remains to a supposedly Neanderthal hand found in the Crimea (see also his discussion on p. 304). Actually, the sole claimant to physical distinction so far discovered in Europe is Neanderthal Man, who is related, more or less legitimately in a relatively restricted region only, to the Mousterian culture series. But there is no guarantee that Neanderthal Man invented the Mousterian culture or that other peoples, who did not resemble him at all, did not use it. Further, there is no evidence that similar cultures are (or were) everywhere contemporaneous. The "Iron Age" culture Europeans who first explored the Pacific found modern-type men in Melanesia and Polynesia in a Neolithic phase, others similar in Australia in a late Mesolithic phase (Abbie, 1951), and yet others in Tasmania in a phase so primitive as almost to defy classification. Clearly, it is as gross an anthropological crime to equate culture with physical characters as it is to equate language with physical characters.

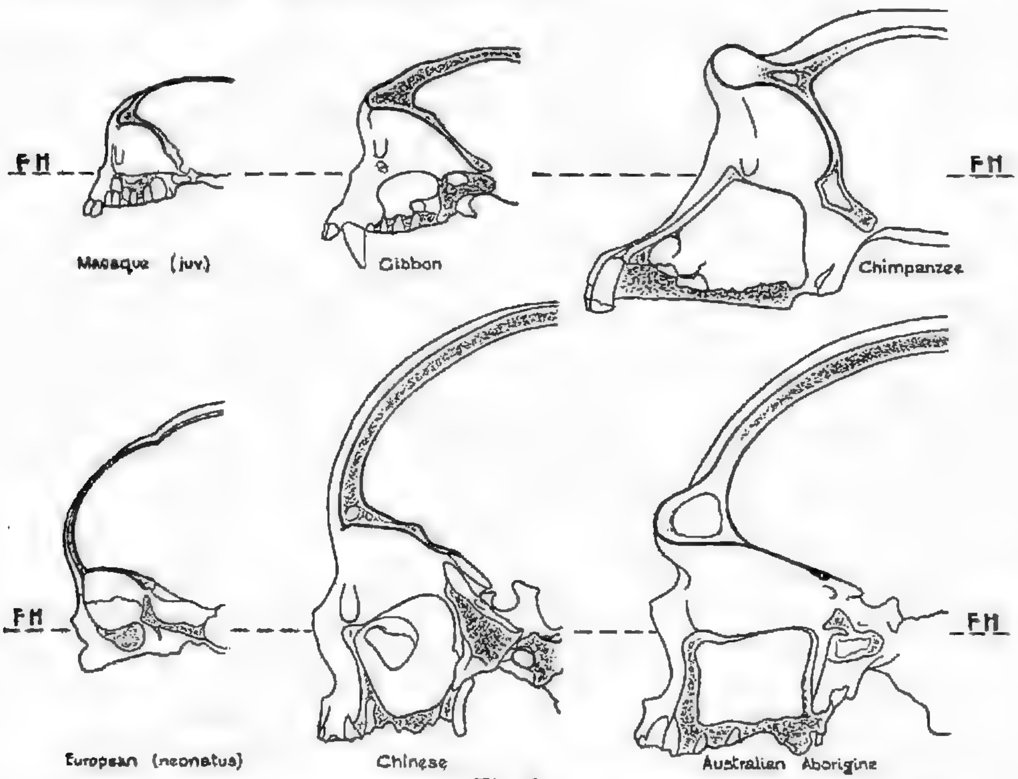

Fig. 2

Sections through the orbital region of various skulls to illustrate the part played by the supraorbital ridge as a roof to the orbit. (F. H. = Frankfurt Horizontal.)

RE-EXAMINATION OF MORPHOLOGICAL CRITERIA

Weidenreich (1946a, p. 201) has pointed out that the tendency to minute sub-classification of fossil man complicates the problem to the point where the leading line of evolution is lost and only singular forlorn specimens remain. The best way to simplify the problem appears to be to discover to what extent the physical non-conformities, i.e., the "simian" features, in human remains are incompatible with the "human" features in the same remains. In other words, it is necessary to determine whether the normal range of human variation is wide enough to embrace the so-called "simian" features.

Since the outstanding event in European physical anthropology of Pleistocene times was the apparently unique intrusion of Neanderthal Man no substantial progress can be made before he is set in his proper perspective. Most of the data for this are craniological.

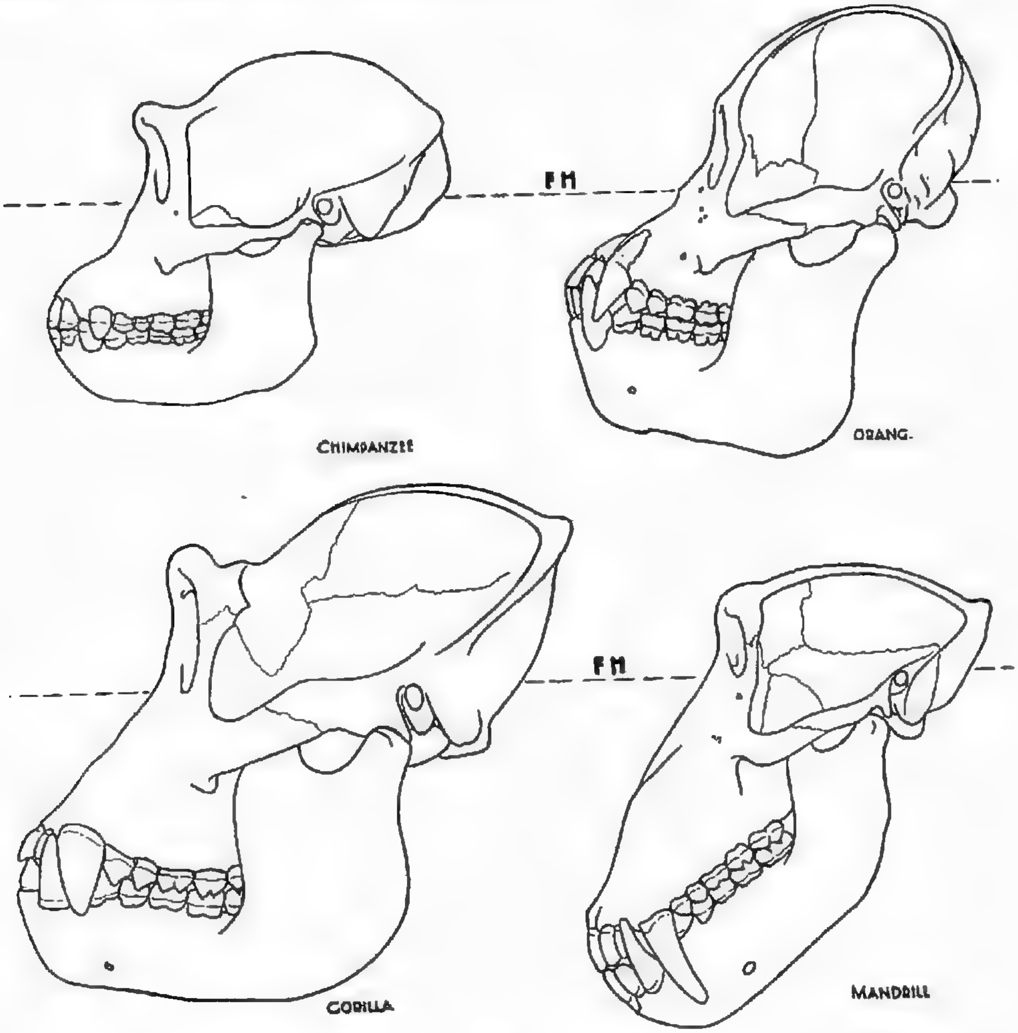

Fig. 3

Primate skulls to illustrate the inconstant relationship between jaw size and size of supraorbital ridge. Note also the combination of facial and alveolar prognathism.

Neanderthal Man

The Brain—According to Hechst (quoted by Le Gros Clark, 1937) a brain as small as 788 cc. has functioned in the normal human fashion. And it would appear that any brain from about 800 cc. to nearly three times as much, may be compatible with human behaviour. As is well known, the brain of Neanderthal Man falls well within these limits. Much of the length of Neanderthal skulls is due to prominent supraorbital and occipital tori. The endocranial index is much higher than the ectocranial index (Weidenreich, 1945 b; Abbie, 1947) and the shape of the Neanderthal brain is well within existing human proportions. Incidentally, most of the energy spent upon trying to deduce cerebral characters from endocranical casts has proved

wasted effort. Symington (1916), Le Gros Clark, Cooper and Zuckerman (1930) and Packer (1949) have all shown that primate casts give little more than maximum dimensions and general proportions. Detailed analysis such as Schepers (1946) attempts for the *Australopithecinae* can have very little value in the present state of our knowledge.

Supraorbital Ridges—The size of these ridges plays an important part in determining whether a skull has a simian appearance or not. Large ridges give a lowering appearance as well as accentuating the slope of the forehead (fig. 5). While large ridges are often associated with large jaws that is not always so, nor, despite widespread belief on the subject, is the primary purpose of such ridges to support heavy jaws and jaw muscles. Bolk (1922) showed that in primates where the face protrudes in front of the skull the eyes no longer lie under the cranial caviety and would be unprotected above unless the frontal bone extended forwards to cover the orbits (fig. 2). The first development of the ridges is, then, related to protrusion of the muzzle but in many primates, e.g., *Hylobates, Papio,* the ridges remain little more than a thin roof to the orbit, which is sometimes almost funnel-shaped as in *Hapale* and *Tarsius*. Certainly in the gorilla the ridges are very massive and are associated with very massive jaws (fig. 3), but even the gorilla shows a wide range of variation (Schultz, 1940). The chimpanzee and orang also have proportionately large jaws but the ridges are much less prominent. The orang, indeed, with more massive—but less protuberant—jaws than the chimpanzee, has relatively inconspicuous ridges. Yet more striking, the mandrill has very protuberant jaws and strong associated musculature but the ridges are little more than terminal thickenings of a thin orbital roof. The Miocene apes of East Africa also combine prominent jaws with very little ridge formation (Le Gros Clark and Leakey, 1951). However, the fact that both the orang and the Miocene apes combine very protuberant jaws with almost no ridge formation indicates that Bolk's views do not provide a complete explanation for the ridges.

In hominids a similarly mixed association can be shown. The *Pithecanthropinae* had both large ridges and large jaws. But Broken Hill Man, with ridges as large as the gorilla, had much smaller jaws, while Piltdown Man, with no particular ridge development, had simian-type teeth and jaws. Not all Australian aborigines are markedly prognathous (fig. 5), but even in those which are the development of the ridges varies widely and the brow ranges from an almost purely Neanderthal type to an upright smooth forehead of which any European could be proud (Abbie, 1951). The aboriginal skull described by Burkitt and Hunter (1922) combined a Neanderthaloid calvaria with facial orthognathism and alveolar prognathism. Negroes are typically prognathous but lack any marked ridge formation. Europeans and other ethnic groups also show a wide range of ridge development associated with an equally mixed assortment of jaws. On the other hand, the low retreating forehead of Lord Darnley had little supraorbital formation (Pearson, 1928).

Clearly, the size of the eyebrow ridges can vary independently of jaw size, and it is not possible with certainty to infer from any given calvaria what the jaws were like or from any set of jaws what the calvaria was like (fig. 5). It was failure to recognize this fact that led to the controversy over the Piltdown remains. It has been shown on statistical grounds that there is no correlation between shape of head and size of jaw (Abbie, 1947). Even without statistical support it seems equally clear that there is no correlation between ridge size and jaw size. In other words, these features vary independently.

Occipital torus—This has been considered in detail by Weidenreich (1940 b). He points out that the human torus is not a purely muscular marking like the nuchal crest of the gorilla and he believes that the torus, together with the zygomatic arches and supraorbital ridges, provides a strong buttress round the base of the skull to withstand the thrust of massive jaws and their musculature. His opinion cannot be accepted without some reserve. As already noted, there is no necessary relation between size of jaws and supraorbital ridges; nor does the view account for the absence of a torus in Piltdown Man, despite the apparently simian jaws. And what role does the nuchal crest of the gorilla play in this context?

Mastoid Process—A small process is considered a simian character, a large one more human. This cannot be wholly true: in the gorilla the process shows a wide range of variation (Schultz, 1950) and the same applies to other anthropoids (fig. 4A). While small processes are common in the Australian aborigine there is a wide range up to as large as in any European (fig. 4B). Moreover, a small process may be associated with either a small or a large occipital crest, and similarly for a large process.

Jaws and Teeth—Protuberant jaws are considered an anthropoid character, straight jaws human; but there are all intervening grades.

Facial prognathism is produced by elongation of the jaws as a whole, alveolar prognathism depends mainly upon protrusion of the anterior teeth and the alveolar margins. Frequently the two kinds are combined—as typically in the Neanderthaloid, Australian aborigine and negro—but this is not always so (Burkitt and Hunter, 1922; Parsons, 1930). In primates, at least, true facial prognathism depends mainly upon the antero-posterior length of the crowns of the lateral teeth—molars, premolars and often the canines (figs. 3, 4C, 6). Long teeth require long jaws to house them.

Alveolar prognathism is rather more complicated. In apes it depends to some extent upon the size of the canines and their associated diastemata. That is not an important factor in the human, even though a maxillary diastema has been described for *Pithecanthropus* IV (Weidenreich, 1946 a) and for a modern negress (Schultz, 1948).[1] At least one contributory cause in the production of alveolar prognathism appears to be a discrepancy in the size of the intra- and extra-alveolar portions of the teeth. Narrow roots widening to broad crowns will produce a splaying out of the alveolar region, both laterally and frontally (fig. 4C, gorilla). This involves mainly the canine-incisor series, with more or less acute alveolar slope according to the degree of crown-root discrepancy. In the mandible the symphyseal slope might well amount to a "simian shelf". Since tooth size varies independently of jaw size (Begg, 1939), varying grades of dental disproportion will produce corresponding grades of alveolar prognathism. Several such grades are found in the Australian aborigine, with reciprocal degrees of prominence of the chin (fig. 4C).

The Heidelberg mandible, which some consider belongs to the Neanderthal series, can now be matched by "modern" human examples, both ancient and recent (Keith, 1913; Weidenreich, 1943).

Taurodontism—This was considered a specific peculiarity of Neanderthal Man (see Keith, 1929), occurring in all grades from a minor enlargement of the molar pulp cavity up to its "typical" condition. However, early degrees of taurodontism have since been described in a South African fossil as well as in some of the Palestinian remains (Keith, 1931). According to Weidenreich (1943) taurodontism has also been found in orangs and in Esquimaux. It appears occasionally in modern white man (pl. v). On the other hand,

[1] Also recently observed by the writer in a living aborigine.

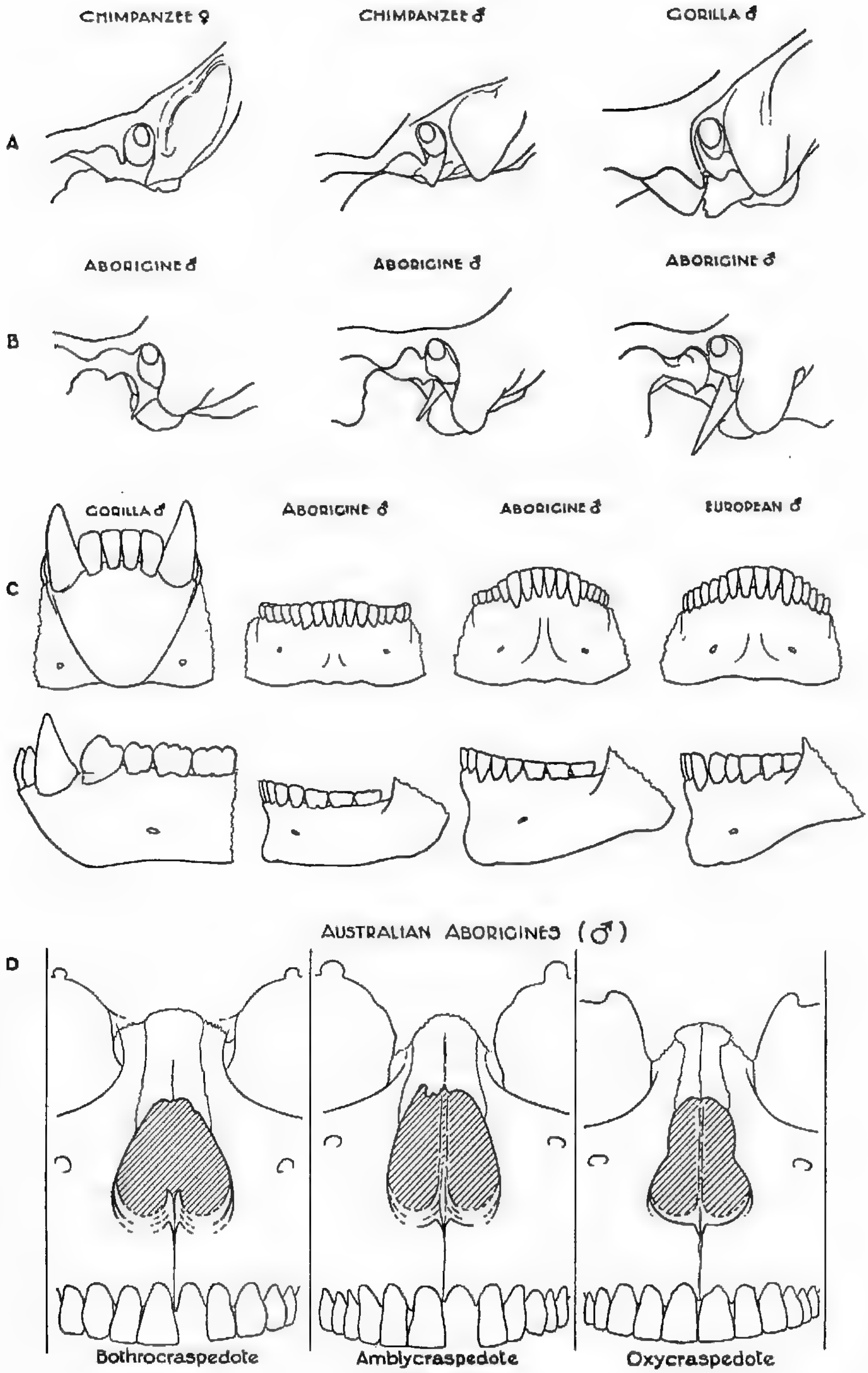

Fig. 4

(See bottom of facing page for description)

one of the most "typical" of Neanderthal skulls—La Ferrassie—betrays no evidence of taurodontism (Boule, 1923).

Analysis of Campbell's (1925) observations indicates that the crown pattern of Neanderthal molars does not differ significantly from that of the Australian aborigine. There is no evidence that this, in turn, differs significantly from that of the European. Consequently, there is no reason to believe that in any particular the molar teeth set Neanderthal Man specifically apart from the rest of humanity (see Coon, 1939, p. 25).

Narial Margin—This presents an outstanding non-conformity in Neanderthal Man since he is typically as oxycraspedote as the modern European (Keith, 1929), irrespective of any "simian" characters the rest of the skull may betray. The Australian aborigine presents all grades from an almost "simian gutter" to an almost European condition (fig. 4D), again irrespective of the presence or absence of "simian" features elsewhere. A similarly mixed association can be found in the skulls of other peoples and it seems clear that the formation of the narial margin varies independently of the remainder of the skull.

Foramen magnum—A relative backward displacement of the foramen magnum described for some Neanderthal skulls was considered evidence for a stooped, shambling gait. However, Sergi (quoted by Weidenreich, 1947) has shown that there is no evidence that the position of the foramen in Neanderthaloids taken over all differs significantly from that in modern man. In the so-called Dinaric types of modern Europe (Coon, 1939) both the ears and the foramen magnum are placed relatively posteriorly, yet the Dinarics are as upright as any other Europeans. The argument for a Neanderthaloid peculiarity in posture and gait thus loses much of its force.

General—With the possible exception of Heidelberg Man, Neanderthal Man's predecessors were less ape-like than he. Swanscombe Man is indistinguishable from modern man, while the Stenheim and Ehringsdorf remains are merely "Neanderthaloid". The same applies to the Tabūn and Galilee skulls of Palestine (McCown and Keith, 1939) and to the Solo and Wadjak skulls of Java. Coon (1939) describes Neanderthaloid characters in upper Palaeolithic, modern-type, skulls, Burkitt and Hunter (1922) have done the same for a recent aboriginal skull, while the recent European Gardarene skulls (Keith, 1931) are remarkably Neanderthaloid. Further, skulls which betray many "Neanderthal" features can be seen today in any European community. In fact, both before and since the Neanderthal series, and also running parallel with it, are all forms intermediate between it and the "modern" type. Under the circumstances there seems to be no justification for distinguishing Neanderthal Man as a separate species, or for Coon's (1939) view that the intermediate grades, e.g., in Palestine, are the result of interbreeding between Neanderthaloids and moderns. On the contrary, the only conclusion justifiable is that Neanderthal Man, even in his extreme form, is no more than a local specialization within the normal range of human variation. This is in harmony with Weidenreich's (1943) view.

DESCRIPTION OF FIGURE 4.

A. Variously sized mastoid processes in anthropoids.

B. The same in Australian aborigines.

C. Gorilla's mandible to illustrate alveolar prognathism; two extremes in the aboriginal series; a European for comparison.

D. The narial margin in Australian aborigines to illustrate the wide range.

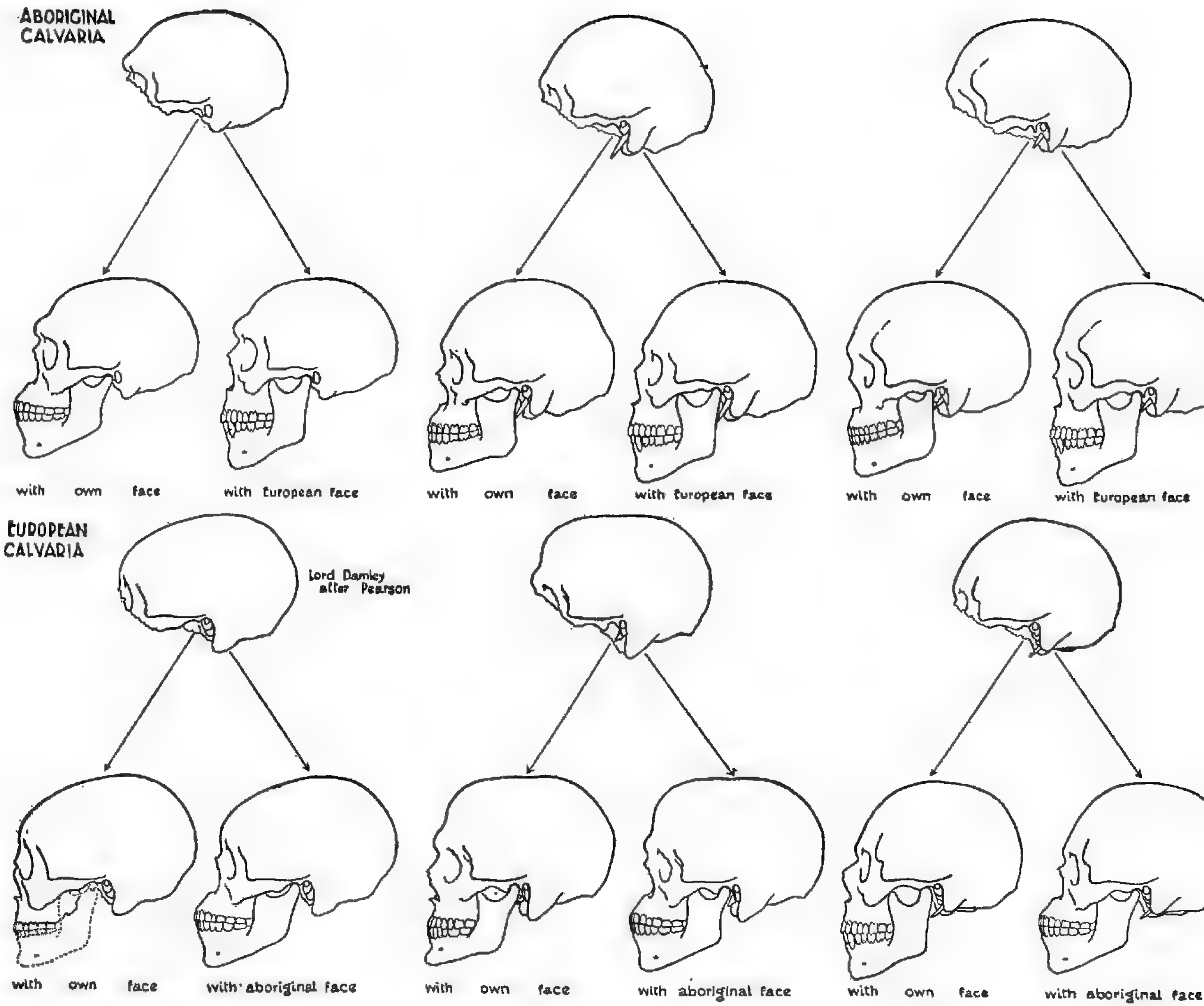

Fig. 5

One aspect of the cranial mosaic-interchanging faces and calvariae. Any of the combinations is possible and they indicate the danger of attempting to reconstruct faces from calvariae or calvariae from faces.

THE PHYSICAL MOSAIC

There is growing evidence that the skull is composed of a mosaic of features which, within wide limits, can vary independently of one another. That is the case with head length, head breadth and size of jaws (Abbie, 1947). The maximum head breadth, in turn, may be either frontally as in Basques or in the parietal region as is more common. It also appears that head height can vary quite considerably in skulls of the same cranial index (see Coon, 1939, p. 127). And it has been noted that tooth size and jaw size vary independently. The present survey indicates that narial margins, supraorbital ridges, occipital ridges and mastoid processes also vary independently.

All this is perfectly intelligible on the particulate theory of inheritance—each feature being determined more or less independently by its own special gene or genes (Dobzhansky, 1937; Huxley, 1942). The most reasonable interpretation seems to be that these developments depend more upon differential growth processes than upon evolutionary or functional factors. When such features attain exuberant proportions it appears best to regard them simply as examples of extreme differentiation carrying normal lines of development to excess, but such excess need not affect all possible points equally or simultaneously.

What applies to the skull applies equally to the rest of the body. That, too, appears to comprise a mosaic of independently variable features held together in only loose harmony. There is plenty of evidence for such independent general variation in the works of Davenport (1926), Krogman (1941) and others. The association of physical characters in a wide variety of permutations and combinations, and the fixation of more stable associations under conditions of initial isolated inbreeding in particular environments, account adequately for both the wide range of human variation and the incidence of more or less distinctive ethnic groups.

Evidently, if these features are normal individually they are equally normal in combination. It is, therefore, of no moment if several such features occur simultaneously in a single person to give a rather more ape-like appearance than is considered customary for "modern" man.

An apparently incongruous assemblage of physical characters proves a stumbling block only to those obsessed by too rigid a preconception of what the line of human evolution should have been. The principle of "correlation of parts" serves well enough when comparing animals of different orders or genera, but it is only misleading when applied to minor differences of degree within what appears to be a single species. Any individual physical feature may appear anomalous in some setting, but provided the feature itself falls within the normal range of human variation there is no reason why it should not form a normal component of any human physical pattern.

Many of the difficulties of interpreting human fossils have arisen from comparing an isolated extreme example with a modern mean; comparison with a modern range of variation would have disposed of some of those difficulties. This point is made by Schultz (quoted by Weidenreich, 1946 b) and by Weidenreich himself. It is becoming increasingly apparent that a so-called "ethnic type" is no more than a statistical assemblage of independent variables of which there is rarely any single complete concrete example. Unless a more flexible approach is adopted physical anthropology will qualify with chemistry as "the science of things that don't exist".

Taking these considerations into account it will be seen that there is no reason why the anthropoid *Australopithecus* should not have humanoid teeth

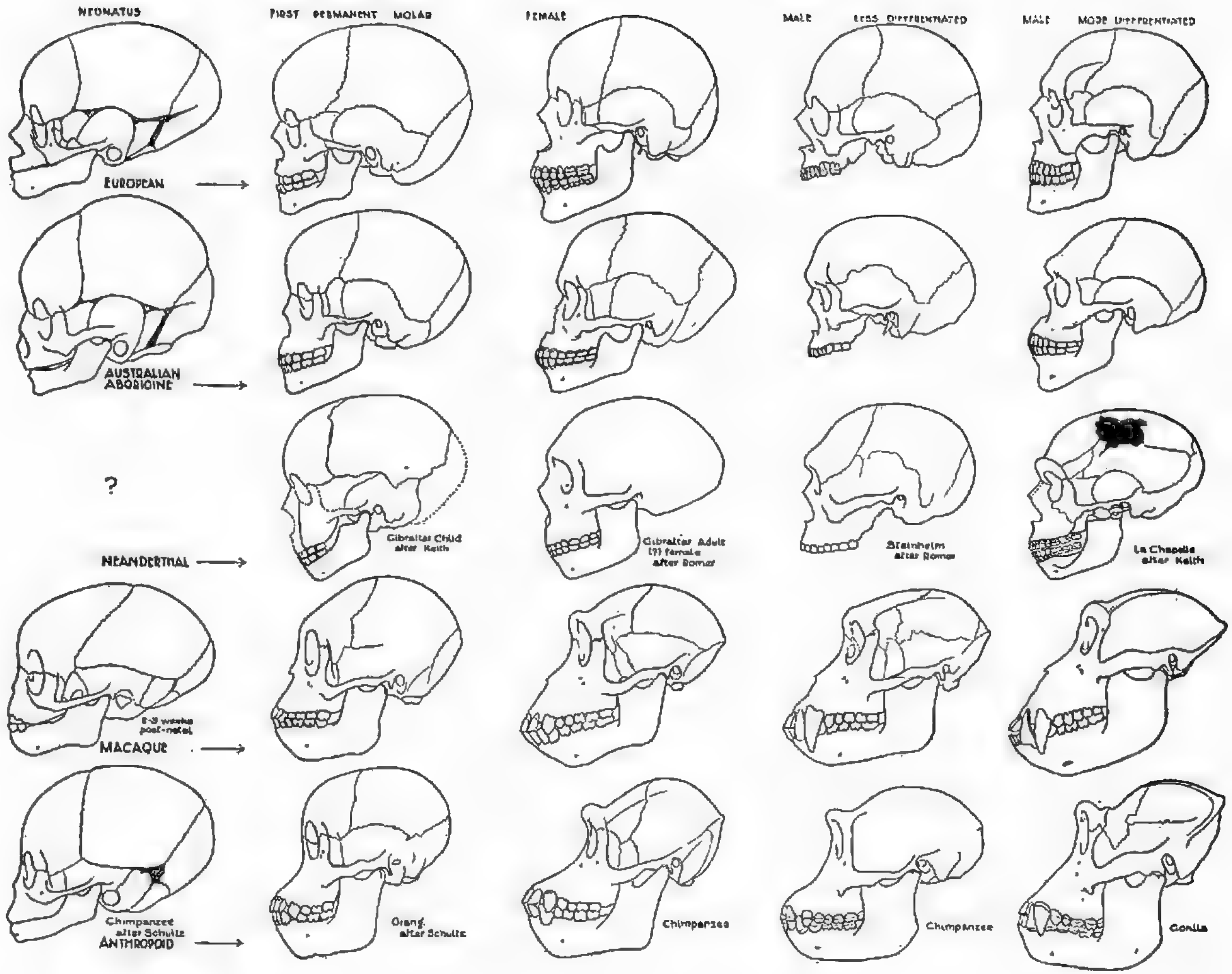

Fig. 6

Primate skulls to show how they differentiate to varying degrees from a relatively common neonatal form. To facilitate comparison they are all drawn to approximately the same size. The female chimpanzee is from a second-molar skull kindly presented by Dr. Adolph Schultz.

and limbs or why the human Piltdown skull should not have anthropoid jaws and teeth. Equally, there is no reason why the more anthropoid skull of *Pithecanthropus* should not be associated with a human-type femur or the less anthropoid skull of Neanderthal Man with a more simian-type femur. This renders rather futile such debates as to whether or not the Grimaldi remains are negroid and Chancelade skull esquimoid. Both can be matched within the Australian aboriginal range—and probably within other ranges—of human variation.

Apart from the whale and the elephant man has the largest brain known, and apart from the marmoset—*Hapale*—he has the highest brain/body-weight ratio. The combination of these two factors appears to provide the necessary neural substratum for the wide range of socio-economic variability that distiguishes man above all other animals. When, therefore, we look for something distinctively human we look for a primate with a cerebral capacity of 800 cc. or more. That includes all the disputed examples of humanity except the *Australopithecinae*. With that possible exception we have no right to consider any recognised hominid as being anything else but human, without any specific—much less generic—distinction. Within that cerebral range, too, there is no warrant to regard any individual or group as necessarily of a higher or lower order of mental ability.

A POSSIBLE COMMON STEM

At present the most we can say about early man is that he probably appeared first in the lower Pleistocene and that every example found so far had a cranial capacity above the required minimum. We know that some kinds had more anthropoid characters—particularly in their skulls—others less (although this fact appears to have little ethnological significance). We know, too, that on a statistical basis man has shown a more or less steady increase in mean stature and decrease in mean head length. On the cultural side we have evidence of a fairly progressive environment control which started slowly but has steadily accelerated up to the present day. That, however, is all we know with certainty in our search for clues to the factors behind evolution.

Two possible clues emerge. One is the progressive increase in stature and in brachycephalization, the other is the progressive control of the environment. There is now ample evidence for the increase in stature (see e.g., Le Gros Clark, 1945) and there is abundant evidence that such an environmental improvement as better nutrition can effect such physical improvement, even within a few years (see e.g., Le Gros Clark, 1939; Abbie, 1946, 1948 a). The same applies to immigrants to a more favourable environment (Boas, 1940; Shapiro, 1939). Boas, Shapiro and others have also shown that environmental improvement produces alteration in head shape. Analysis of this alteration indicates that the change is towards a mean cranial index within the foetal range of 78-82 (Abbie, 1947). On the evolutionary time-scale there is evidence that these physical changes have been most apparent in those peoples who have made most progress in controlling their environment.

Progressively longer retention of the foetal form of skull is an example of the foetalization first described by Bolk (1926). Other human examples are the relative lack of hair and the lack of pigment which characterizes some human ethnic groups (de Beer, 1940). Increase in stature, which connotes an extension of the foetal capacity for growth, is also an expression of foetalization—even though the outcome is further removal from the foetus

physically. The concept of foetalization makes it necessary to reverse the usual ideas on human evolution.

A glance at the foetal skulls of most primates shows how essentially similar they all are, with smooth round crania and small jaws (fig. 6). Such primates as the gorilla, which subsequently develop large jaws and teeth and heavy supraorbital and occipital ridges, have differentiated farthest away from the foetal standard ("gerontomorphism"). Those, such as man, which show a progressively stronger tendency to retain the smooth skull and small jaws have differentiated least ("paedomorphism"). Anthropoid characters are, then, not primitive but specialized: the less anthropoid the characters the more primitive and less specialized they are (see Wood Jones, 1931). Evolution up to man has not been marked by a progressive reduction of simian features as is usually assumed; it is distinguished simply by failure to attain the simian degree of differentiation in a number of physical characters.

Not all modern human physical characters are foetalized, of course. A highly-arched nose, large mastoid process, prominent chin and the human foot are quite the reverse. Nevertheless, it is apparent that foetalization underlies most of the major elements characteristic of human evolution. Mere prolongation of the growing period permits an increase in overall dimensions which, up to an optimum that is still uncertain, confers a definite advantage in the struggle for existence. Even more important, such prolongation of the growing period allows the brain to acquire dimensions considerably greater than in any other primate (Abbie, 1948 b). Moreover, retention of the foetal form of skull provides the maximum cranial capacity with the minimum expenditure of bony material (Abbie, 1947).

Pursuit of the concept of foetalization casts an interesting light upon the problem of human origins. If all primate foetuses are so alike, at what stage do they become distinguishable from one another? In other words, how far back into foetal existence must one go to find an indifferent common generalized form that might become any kind of primate?

If a common generalized foetal form could be discovered the problem of man's ancestry would be much closer to solution than it is now. Purely as a working hypothesis, such a form is visualized here as resembling a human embryo of about seven weeks' gestation (fig. 7). At that stage the total development is that of a generalized primate and, while the digits of the hand are differentiated, those of the feet are not, so that there is no external indication whether the great toe will become free and apposable as in apes or remain fixed and adducted as in man. Although there is inadequate information on other primate embryos it seems likely that they all pass through such a stage. While it is true that the ultimate fate of this embryo is already determined at conception, it is equally true that a minor shift in emphasis could direct differentiation into any of the lines that end up each in its own specific kind of primate.

This is probably a gross over-simplification of the problem, but it serves to illustrate the thesis advanced here, namely, that a common ancestry for the primates is to be sought amongst primate embryos, not adults. And if there are different kinds of humans—which appears unlikely—then their common ancestry is to be sought in the same source. That is merely an extension of von Baer's modification of the Meckel-Serres law. If it is correct man's ancestry and affinities are not to be found by comparison of primate adult characters, and it is irrelevant to the problem whether man's adult physical make-up lies closer to the shrews, tarsiers, lemurs, monkeys, apes or any other that could be thought of. Theoretically, any of these

could by some embryonic twist have given rise to the human stock at any time. Consequently, there is no pressing need to go really far back into primate ancestry to discover a form sufficiently generalized to have given rise to man.

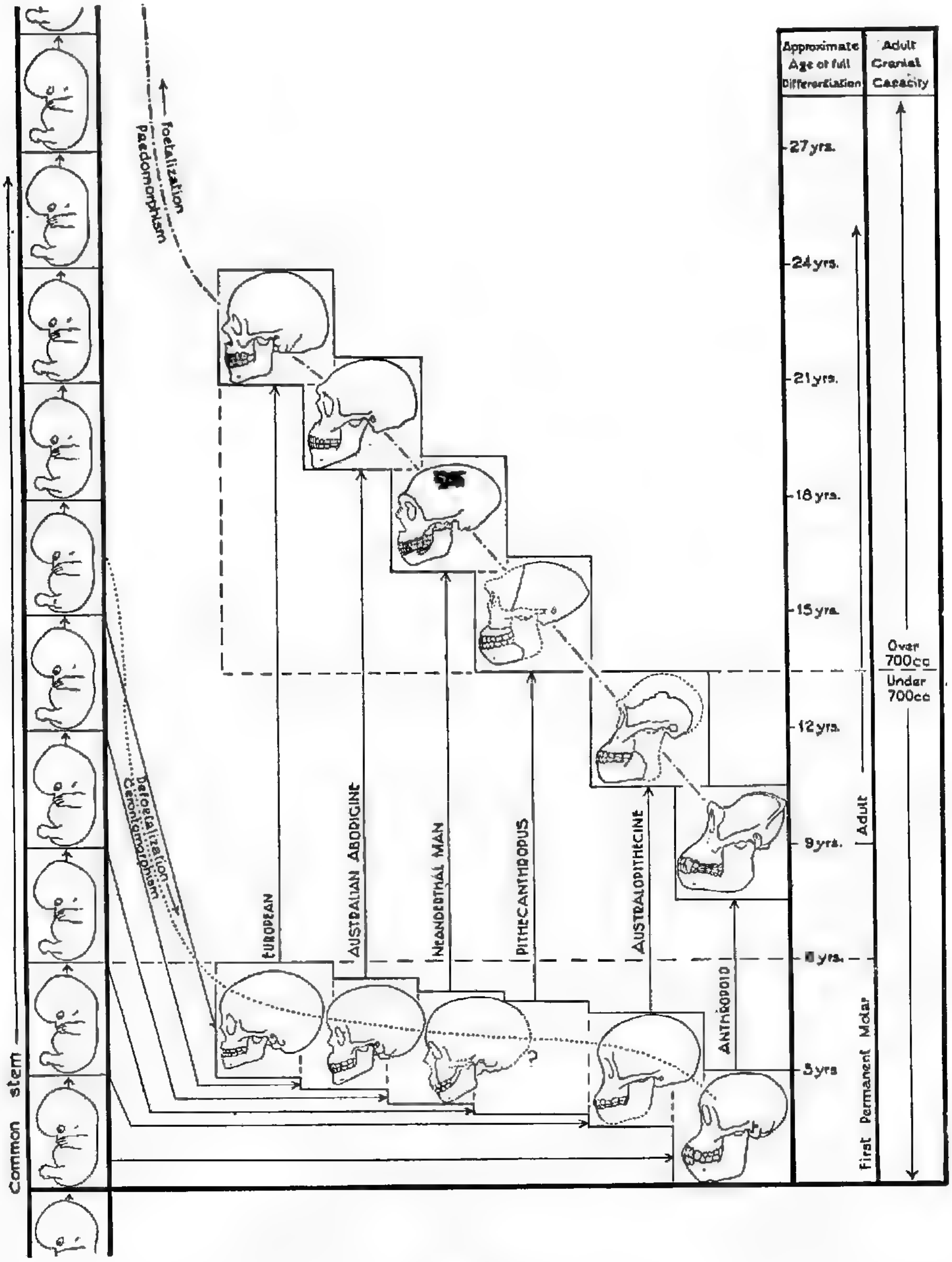

Fig. 7

A scheme to illustrate the suggested common primate stem, and the manner in which distinctive forms of various primates have been derived from it by a combination of the processes of gerontomorphism and paedomorphism.

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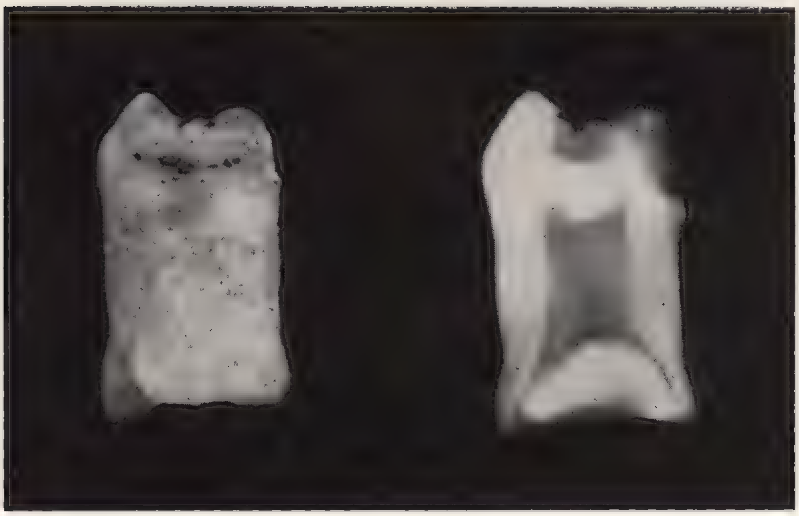

"Taurodont" molar of recent European origin from the Ramsay Smith Collection in the Adelaide Dental Hospital. Skiagram by J. A. Cran, M.D.S.

TERTIARY FAULTING IN NORTH-EASTERN EYRE PENINSULA, SOUTH AUSTRALIA

BY KEITH R. MILES

Summary

A distinctive pattern of meridional block-faulting in the country between Whyalla and Cowell, north-eastern Eyre Peninsula, has been developed as a result of movements accompanying the foundering of the Spencer Gulf region during the Plio-Pleistocene. The meridional trend of many of the Tertiary fault scarps is a reflection of pre-existing foliation trends in the Pre-Cambrian bedrock. Mapping of the scarps was greatly assisted by the use of aerial photographs. There are many examples of dislocation and rejuvenation of senescent pre-Tertiary drainage as a result of the faulting movements. The region provides excellent material for the study of the results of geologically youthful faulting in soft "overmass" sediments.

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INTRODUCTION

Early in 1948 a strip of country approximately 28 miles wide, running northerly from latitude 33° 45′ S. near Cowell for about 104 miles to latitude 32° 15′ S. beyond Port Augusta in the north-eastern corner of Eyre Peninsula, was flown and photographed by units of the Royal Australian Air Force at the request of the Department of Mines of South Australia. Later in the same year the writer, assisted by other officers of the Mines Department, commenced an intensive geological survey of the region, which includes the economically important iron-rich hills of Iron Knob and the Middleback Range. At the time of writing this survey was still in progress, but regional mapping of most of the country lying between the Middleback Range and the coastline of Spencer Gulf had been completed.

This mapping, carried out on a scale of 37-40 chains to an inch, using the aerial photographs already mentioned, has revealed a number of very interesting features of geology and physiography, not the least of which is an extensive pattern of block-faulting, which is the subject of the present paper. Faulting in this area has been known for many years and was first identified and described by R. L. Jack (1914) following a reconnaissance geological and hydrological survey of parts of Counties Jervois, York and Buxton. Later it was recognised that the whole of the eastern coastline of Eyre Peninsula was bounded by block-faulting. C. Fenner (1930) referred to this as the "Lincoln Fault" in discussion of the major structural and physiographic features of South Australia, and later (1939) compared some of the faults with the "dirt scarps" of the Para Fault immediately west of the city of Adelaide.

During the course of the present survey it has been possible, with the aid of the air photos, to recognise and delineate the faults in considerable detail and to distinguish their characteristic features.

PHYSIOGRAPHY AND GEOLOGY

The greater part of the region under review is physiographically mature to senescent, flat and low lying or very gently undulating with only occasional

* Department of Mines, South Australia.

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isolated hills or ridges. Close to the coast is a long narrow strip of salt-water marshes and sand-dunes standing just above highwater level, often fringed on the seaward side by mangroves, and extending along the coastline southwards from Whyalla to Cowell and beyond.

Beyond these marshes the land gradually rises to a flat soil-and-alluvium-covered coastal plain standing 50 to 100 feet above sea level, covered with saltbush, bluebush and myall. This coastal plain ranges from two to eight miles in width, but near Whyalla is broken by Mount Young and the Whyalla Hills. It is interrupted to the westward by the system of north-south fault scarps to be described below. These have the total effect of stepping up the plain to the westward, in general block by block, to a height of about 400-450 feet.

The upper plain is a base-levelled, gently undulating tableland extending westwards to the Middleback Range and well beyond. The general level stands at between 450 and 650 feet above sea level. To the westward and south-westward of Whyalla this plain is broken by a number of rocky north-south-trending ridges such as the Middleback Range (900-1,400 feet) and Moonabie Range (about 850 feet), but farther southwards it is relieved only by low, smooth, rounded hills. To the northward and north-westward of Whyalla are the dissected remnants of an original higher level tableland which extends far to the north-westward of Port Augusta.

Drainage channels within the area under review are well defined only in the immediate vicinity of where they rise amongst the higher level ridges. Within the plains, with few exceptions, they consist of broad and diminishing flood lines. Not even the best-defined drainage channels such as Salt Creek or Myall Creek reach the sea. To the westward of the Middleback Range a decadent southerly drainage is marked by a number of salt lakes flanked by gypsum dunes. Eastward of the range a senescent drainage system trending southerly to south-easterly has been partially dislocated by the block faulting. Short fault-scarp consequent water courses, such as Deep Creek, are in process of eroding back some of the recently formed scarp faces.

A very great part of the area under discussion is covered by geologically recent superficial deposits of soil and alluvial sands and clays, and ubiquitous travertine cement. These deposits mantle almost all of the coastal plain between Whyalla and Cowell and much of the upper plain. To the southward and westward of the Middleback Range sand dunes forming continuous lines of parallel ridges trend N.W.-S.E. and cover much of the country.

At scattered localities on the flanks of the fault scarps are exposed the remnants of what were probably extensive deposits of grit and sandstone overlying shell-rich marine limestone (Pliocene) formed during an incursion of the sea over much of the areas occupied by the coastal and upper plains. This limestone lies directly upon Pre-Cambrian bedrock.

The basement rocks underlying the plains and exposed in the low rises of the undulating country, and in the hill ridges and the upper tableland, are believed to comprise a considerable range of rock types—from sandstones, grits and conglomerates of probable Cambrian age and basal grits and quartzites of the Proterozoic Adelaide System, to Archaean igneous and metamorphic rocks. The latter include steeply-folded banded iron formations and associated schists of the Middleback Range and also a complex series of schists, gneisses and migmatites, and foliated granitic rocks. Later igneous rocks include coarse porphyritic granite, felspar porphyry and dolerite-amphibolite. Composite quartz veins occupy a number of extended fissures in the older rocks.

It is apparent that the area under review has been the subject of some extremely long periods of erosion which have continued up to geologically recent times. This is reflected in the generally base-levelled character of much of the

topography, the high level plateau of the Cambrian sandstone and conglomerate formations, and the gently undulating to flat upper plain with its pediments of fairly deeply weathered granitic schists, gneisses and migmatites.

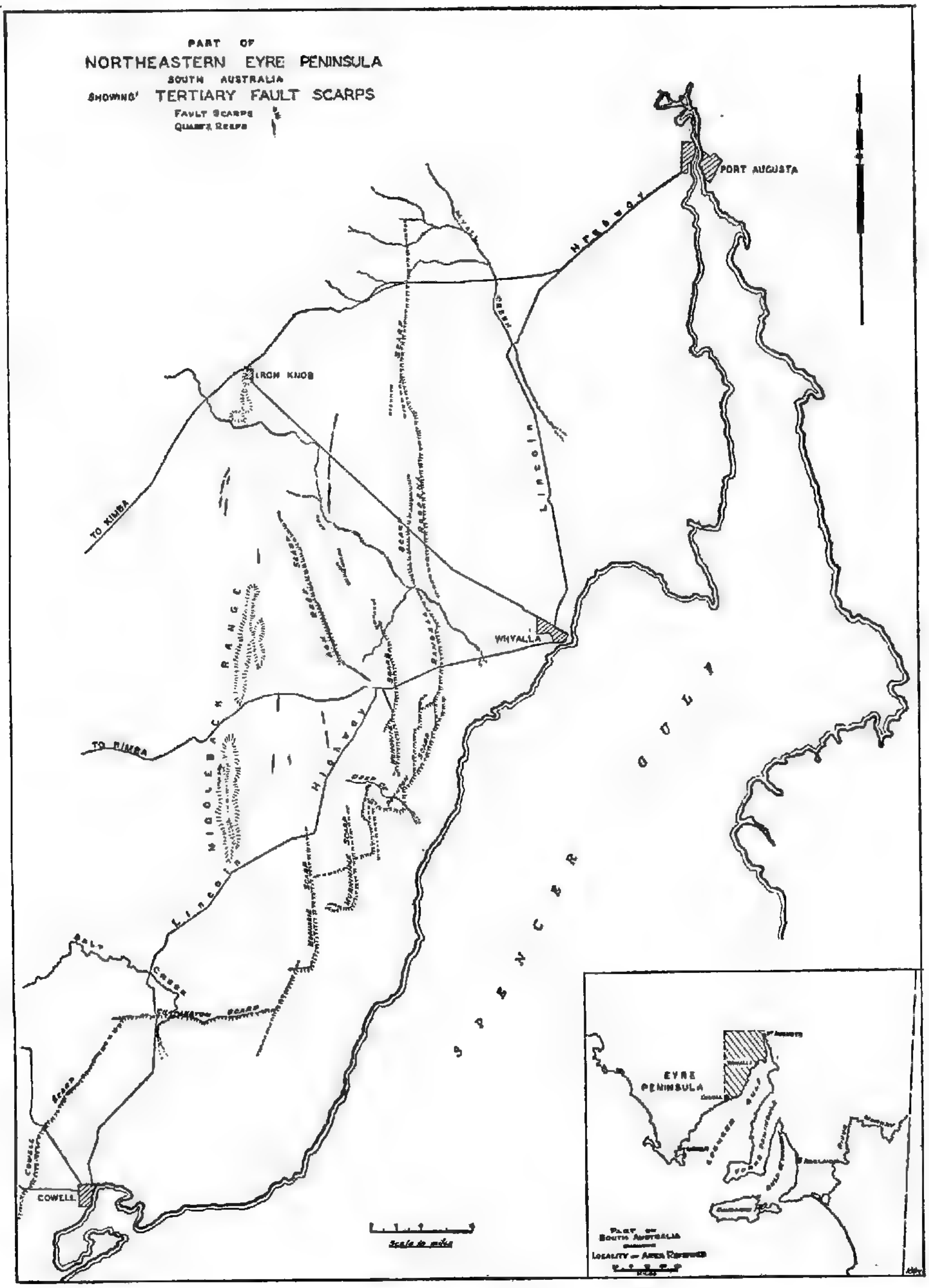

Fig. 1

THE FAULT SCARPS

The distribution and pattern of faulting has been determined in the field and from the aerial photographs by recognising and delineating the characteristic topographic features. Their distribution is shown in fig. 1.

In the field a fault scarp can often be distinguished by the occurrence of a rise or fall in otherwise almost perfectly peneplained country, and by the remarkable continuity and straightness of the resulting escarpment (fig. 2). In slightly undulating country, or where the fault displacement has been small, it may become virtually impossible to recognise on the ground the characteristic topographic features of faulting. From the aerial photograph, however, it is possible to identify and delineate with ease the fault scarps of all sizes down to those in which the total displacement has been no more than a few feet. They appear as typically straight or gently curved light-coloured lines which usually truncate all other features of topography, soil and vegetation distinguishable in the photograph (pl. vi, fig. 1).

The principal fault scarps in the region lying between the Middleback Range and Whyalla have a strong general meridional trend with a lesser development of cross-linking scarps trending east-west or slightly south of westerly. For convenience of description and identification these scarps have been given names as shown in fig. 1.

The first scarp encountered in travelling from Whyalla to Iron Knob is the Roopena Scarp which crosses the road and railway near Roopena Siding, at about 13 miles from Whyalla, and extends northerly for about 20 miles. This is an east-facing scarp and has an average height of about 10 feet, but for many miles it rises no more than five or six feet above the eastern plain (pl. vi, fig. 2). Branching of the scarp at about 12 miles north of the Whyalla-Iron Knob road indicates a splintering of the fault line at this point.

The next main scarp, Randell Scarp, crosses the Whyalla-Iron Knob road at about 15 miles from Whyalla and runs southerly from a point four miles north of the road, in two broad arches, first curving towards the west and then towards the east, crossing the Lincoln Highway at 10 miles west of Whyalla. This scarp traverses the full length of the Hundred of Randell and enters the Hundred of Poynton to the south, where it joins the Poynton Scarp, a bold north-easterly trending feature which, with an east-west trending branch, overlooks the coastal plain to the east and south.

At its northern end Randell Scarp faces westward and attains a maximum height of about 30 feet; but at about five miles south of the Iron Knob road it rapidly loses height and dwindles into the plain, only to re-appear at a few chains farther south, on the same line, as an east-facing scarp which gradually increases in elevation above the coastal plain to a maximum of about 75-80 feet. Approaching Poynton Scarp, its elevation above the Poynton block is about 20-25 feet. Near here a second parallel scarp stopped at 1½-2 miles to the west, forms a splinter block on the Randell fault block.

Poynton Scarp first rises at about three miles south of the Lincoln Highway and trends first southerly and then south-south-westerly for five miles, where it is joined by a branching north-south scarp (maximum height 35 feet), and then swings southerly for several miles. From here Poynton Scarp steps to the westward for about four miles and breaks into a number of north-south splinter scarps, only to swing at right angles, westerly again as a prominent 60 ft. escarpment which can be traced for about five miles, first crossing the Murninnie Scarp and finally dying out against the Moonabie Scarp (pl. vi, fig. 4). A feature of Poynton Scarp has been the discovery of traces of Tertiary marine limestone along

the foot of the scarp at a number of localities. Similar limestone occurs overlying granite-gneiss, on the banks of Deep Creek, on the Poynton-Nonowie fault block (pl. vii, fig. 3). Average height of the scarp is about 45-50 feet.

The next major scarp-line runs roughly parallel to the southern half of Randell Scarp and crosses the Lincoln Highway at about 14 miles from Whyalla. It passes at half a mile west of Nonowie Station homestead and has been named Nonowie Scarp. It is about 14 miles long and has a number of small forks or branching scarps, all facing easterly. Maximum height is about 80 feet near the Lincoln Highway, the scarp reducing to about 15-20 feet as it approaches Poynton Scarp. Here delineation becomes difficult due to undulating outcrops of gneiss on the up-slope side. To the north the scarp extends for some distance at a steady height of about 40 feet, but finally dies out at seven miles north of the Lincoln Highway. Beyond this there are the discontinuous remnants of an irregular west-facing scarp which may represent the northerly extension of the Nonowie fault line, and which suggests that, as with the Randell Scarp already described, a whole block of country in this vicinity has undergone hinged faulting movements about an east-west axis of cross warping.

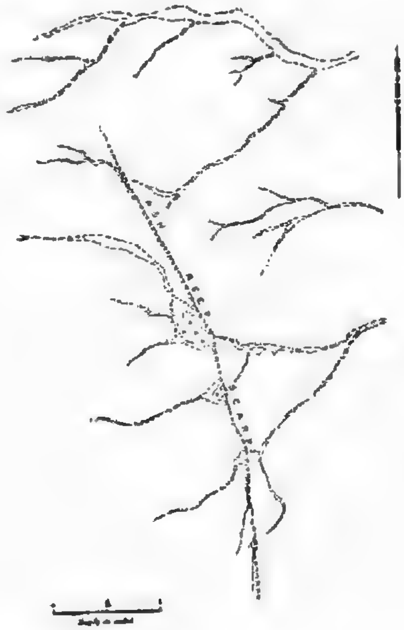

Fig. 2
Pre-existing drainage pattern dislocated by portion of Ash Reef Scarp.

Farther west again is a well-defined topographic feature which starts at its northern end as a west-facing scarp trending south south-easterly. This scarp gradually gives way to a gentle ridge covered by loose quartz rubble, and farther south again where it enters the Hundred of Ash it becomes a long straight composite quartz reef ridge which finally swings south-easterly across granitic gneiss country near the junction of the Lincoln Highway with the Whyalla-Kimba road. This feature has been named Ash Reef Scarp. This is the most westerly of the fault scarps identified in the northern half of the area under review. Maximum height of Ash Reef Scarp is about 40 feet. Where the scarp merges into the quartz ridge its height is reduced to about 15-20 feet above the surrounding plain. The presence of the quartz reefs along the fault line of this scarp is of considerable significance and will be discussed later in considering the age of the faulting.

Murninnie and Moonabie Scarps are two parallel, short and very straight north-south trending scarps, each of which face easterly, dies out to the northward and swings sharply to the west at its southern extremity, producing in turn the effect of two rectangular hinged fault blocks, tilted downwards to the south.

Murninnie Scarp, so named because the workings of old Murninnie Copper mine [Jack (1930), p. 42] are exposed in its flank close to where it crosses Poynton Scarp, rises about 20-30 feet above the Poynton-Nonowie fault plain. Farther south it stands at between 75 and 80 feet above the coastal plain (pl. vi, fig 3). Granite gneisses and migmatites are exposed along much of Murninnie Scarp except towards its southern end, where east south-easterly trending sand dunes spill over the dwindling scarp face.

Moonabie Scarp extends southerly from where it crosses the Lincoln Highway at about two miles east of the Moonabie Range, for about 11 miles to a point where it swings sharply to the west. At Lincoln Highway the total displacement is about 3-4 feet, but this increases steadily to the southward until at about five miles south the maximum measured height of the scarp is about 180 feet (pl. vi, fig. 4). Here on the flanks of the uplifted block is exposed a belt of much felspathised, highly brecciated cherty sediments. Going farther south the scarp face gradually diminishes in height and is transgressed by sand dunes following the regional east south-easterly trend.

Moonabie Scarp ends against a short straight scarp which runs in a south-westerly direction for nearly eight miles, where it fades out in sand dune country. This scarp has an average height of 20 feet and faces south-easterly over the coastal plain. It serves to link Moonabie Scarp with the next prominent feature, the Charleston Scarp.

Charleston Scarp runs east and west at just south of the southern boundary of the Hundred of Charleston. It faces south, has a length of about 12 miles and a height ranging from 10 feet to about 30 feet. Near the scarp boundary much of the uplifted Charleston-Moonabie block is covered by sand dunes. It is breached by Salt Creek in whose banks are exposed considerable thicknesses of presumably Tertiary fluvatile grits and gravels, apparently overlying Precambrian granite and gneiss.

The final scarp in the area under discussion, the Cowell Scarp, can be seen from the coastal plain as a bold scarp feature running continuously in a south-westerly direction from Charleston Scarp at four miles west of Salt Creek to four miles west of Cowell, and well beyond. Maximum displacement along Cowell Scarp is not known, but it probably varies from not less than 50 feet to over 100 feet. Dissection of the scarp near Cowell has resulted in exposures of Precambrian gneisses and metamorphosed sedimentary rocks.

So much for the individual fault scarps—let us now consider the fault scarp picture as a whole. It is apparent from a review of the entire general pattern of faulting in the area surveyed that the general regional movement has been downward to the south-east, along a broad south-west north-east axis, *i.e.*, parallel to the western coastline of Spencer Gulf. Individual scarps have been produced by contemporaneous differential movements of successive parallel blocks of country so that, with a few notable exceptions (*viz.*, the northern portion of Ash Reef, Nonowie and Randell Scarps), in going westward, each has been stepped *upward* relative to the coastal plain, and to each other, or conversely they have been stepped *downward* to the eastward. Furthermore, since the scarps die out to the northward, it appears that the fault blocks have been tilted or warped down to the southward along hinged fault lines. In the exception cited above the fault blocks have apparently been warped along an east-west axis, possibly as a result of

secondary or later fault movements which have reversed the direction of some scarp faces.

This general pattern of faulting is consistent with the type of irregular tearing along the grain of the country which would be expected at the boundaries of a major "graben" or similar down-faulted block which lies oblique or transverse to this regional grain. In this instance the major transverse down-faulting was provided by the "foundering" of Spencer Gulf, the predominant movement being south-east block downward relative to Eyre Peninsula. The regional grain of the country is represented by the foliation trend lines of the Precambrian basement rocks. That some minor tearing movements were along pre-existing fissures or lines of weakness in the older Precambrian rocks is suggested by the development of a relatively youthful fault scarp along the extension of a line of possibly Precambrian or early Palaeozoic quartz reefs (the Ash Reef Scarp). There are, however, other major lines of quartz reefs shown in fig. 1, which although representing ancient fissures and lines of weakness, did not yield during the period of block-faulting movements responsible for the scarps described above.

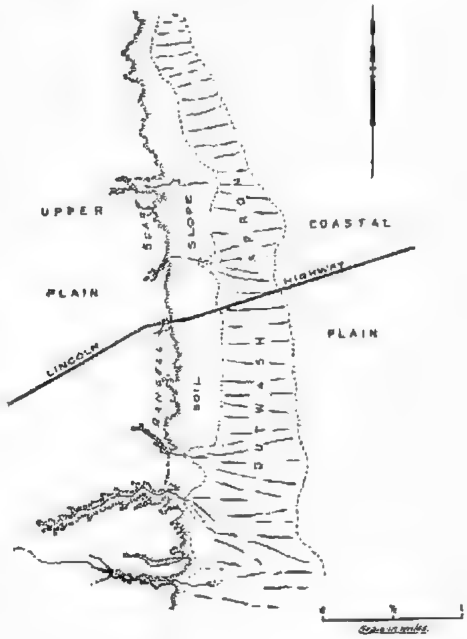

Fig. 3

Portion of Randell Scarp showing early stage dissection and development of scarp-consequent and rejuvenated water-courses.

AGE OF FAULTING

There is ample evidence that the fault scarps described in the preceding section are comparatively youthful features. Perhaps one of the most striking examples of such evidence is the effect of the faulting upon the drainage pattern in many portions of the upper pediment-plain, as revealed in the air photos and by surface mapping.

Much of the present decadent drainage pattern on the upper plain between Whyalla and Iron Knob and the Middleback Range has been inherited directly from, or is unchanged from, the pre-faulting topography, in which a fairly high degree of base-levelling or peneplanation is displayed. In places the faulting has dislocated the drainage, either damming back or diverting old drainage lines or else rejuvenating old channels or promoting new ones.

Fig. 2 shows how development of the west-facing Ash Reef Scarp has dammed back a number of easterly-directed drainage channels and produced several shallow ponds or claypans. This scarp ranges in height from less than a foot at its northern extremity up to 40 feet opposite the largest claypan flat. The scarp line is very straight and entirely undissected by any scarp-consequent drainage channels. It consists of a simple soil slope, or "dirt scarp" of Fenner (1939, p. 86). Other examples of similar claypans or natural dams can be seen along the northern portions of Roopena Scarp where the low east-facing scarp (height 5-10 feet) has transgressed pre-faulting south-westerly drainage.

Fig. 3 illustrates how the faulting has promoted small scarp-consequent drainage channels and rejuvenated senescent easterly drainage on portion of Randell Scarp, near the Lincoln Highway (pl. vii, fig. 2). The scarp face, which has a height of about 70-75 feet is in process of becoming irregularly dissected, and the original soil slope is being modified in its lower levels by the development of an outwash apron of alluvium washed from the crest of the scarp.

As to the precise geological age of the faulting, it is possible to define a lower limit to the faulting period, as the Tertiary marine limestone which, as already mentioned, has been found at the foot of Poynton Scarp and also on the Poynton-Nonowie fault block, is believed to be of Lower Pliocene age similar to the so-called "Adelaidean" (Kalimnan) of the Adelaide-Hallett Cove district. At Deep Creek this marine limestone, which is rich in shell casts, has been cut off against granite-gneiss by a steep-angled fault (pl. vii, fig. 4).

It is probable that the faulting movements continued through the Pliocene and into Pleistocene time, with various isotatic readjustments accompanying the foundering of the Spencer Gulf and Gulf St. Vincent region and the development of the Mount Lofty Horst block. This period coincides with the so-called Kosciuskan Epoch of major block-faulting movements responsible for many mountain features along the eastern coast of Australia.

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Fig. 1

Part of Roopena (right) and Randell Scarps near Roopena Siding, Whyalla-Iron Knob railway. Vertical photo from 15,000 feet. R.A.A.F. photo No. 167, Roopena, run 5.

Fig. 2

Roopena Scarp, a 10-ft high non-dissected scarp. North of Iron Knob road in area illustrated in fig. 1.

Fig. 3

The partly dissected Murninnie Scarp (height 80 feet) from the lower (coastal) plain.

Fig. 4

A south-facing portion of Poynton Scarp, looking E.N.E. from Murninnie Scarp.

Fig. 1
A prominent portion of Moonabie Scarp (height 180 feet).

Fig. 2
The head of a rejuvenated scarp-consequent water-course on the Randell Fault-block, a travertine-capped plateau.

Fig. 3
Tertiary (Pliocene) marine limestone overlying weathered granite-gneiss in the banks of Deep Creek, on the Poynton-Nonowie Fault-block. The limestone boulder in the left foreground has been dislodged from farther up the bank.

Fig. 4
A post-Pliocene fault in Precambrian granite-gneiss at Deep Creek. The marine limestone shown in fig. 3 was down-thrown and preserved by movement along this fault.

BASIC IGNEOUS ROCK OF THE WORUMBA REGION, SOUTH AUSTRALIA

BY ALAN H. SPRY

Summary

A group of basic igneous rocks occurs about twenty miles east of Hawker in the Flinders Ranges. The regional features of the locality have been discussed by the author in a previous paper. The varieties present are described as dolerites and basalts and invariably show the effects of uralitization, saussuritization, etc., due to deuteric and hydrothermal alteration. These basic rocks lie almost entirely in a fault block in the centre of Worumba Anticline, where they have intruded pure and impure dolomites, phyllites and quartzites which are stratigraphically placed almost at the base of the Adelaide System. The intruded sediments show slight regional metamorphism but very little contact alteration.

BASIC IGNEOUS ROCKS OF THE WORUMBA REGION, SOUTH AUSTRALIA *

By Alan H. Spry

[Read 8 November 1951]

SUMMARY

A group of basic igneous rocks occurs about twenty miles east of Hawker in the Flinders Ranges. The regional features of the locality have been discussed by the author in a previous paper. The varieties present are described as dolerites and basalts and invariably show the effects of uralitization, saussuritization, etc., due to deuteric and hydrothermal alteration. These basic rocks lie almost entirely in a fault block in the centre of the Worumba Anticline, where they have intruded pure and impure dolomites, phyllites and quartzites which are stratigraphically placed almost at the base of the Adelaide System. The intruded sediments show slight regional metamorphism but very little contact alteration.

THE BASIC ROCKS

Two major varieties of igneous rocks are found in the area, and the division is made according to prominent lithological characteristics. The medium to coarse grained rocks with ophitic to intergranular texture are called dolerites, while the fine-grained, amygdaloidal varieties are named basalts. These terms replace the "diabase" and "melaphyre" of Benson (1909) and Howchin (1907, 1928, etc.).

There is considerable doubt whether all the basalts are truly extrusive, so that the division is made on a lithological rather than a genetic basis for convenience.

Field Relations

The basics are restricted to the disturbed axial zone of the Worumba Anticline, and while the majority intrude the phyllite-dolomite fault block there are a few which have penetrated the Sturt Tillite in the area about Morgans Creek. Text figure 1 shows the distribution of the igneous bodies with each occurrence numbered. The folding and faulting within the fault block was too complex to resolve in the time available and consequently only structural trends are indicated in this map.

The group numbered 5 to 15 (excluding 13 and including B. 1) appear to be very closely related. Particularly in the southern part, the area appears to be almost completely underlain by igneous rock with only narrow strips of sediment separating individual intrusions. The sediment may be remnants of the roof over a large solid mass.

Number 44 is a narrow elongated mass which forms the ridge just west of Mount Craig and is shown in more detail in text figure 2. It appears as several small, disconnected outcrops in the south, then as a solid, curved, dyke-like mass. It is by far the most interesting and important of all the intrusives, as it shows clear evidence of differentiation, differential alteration, metasomatism and mineralization and warrants more attention than was allowed in the field observation.

The group numbered 49 to 53 shows a distinct meridional grouping and strongly suggests a line of intrusions along a fracture. It is notable that the

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* Section of an Adelaide University Commonwealth Research Grant Thesis.

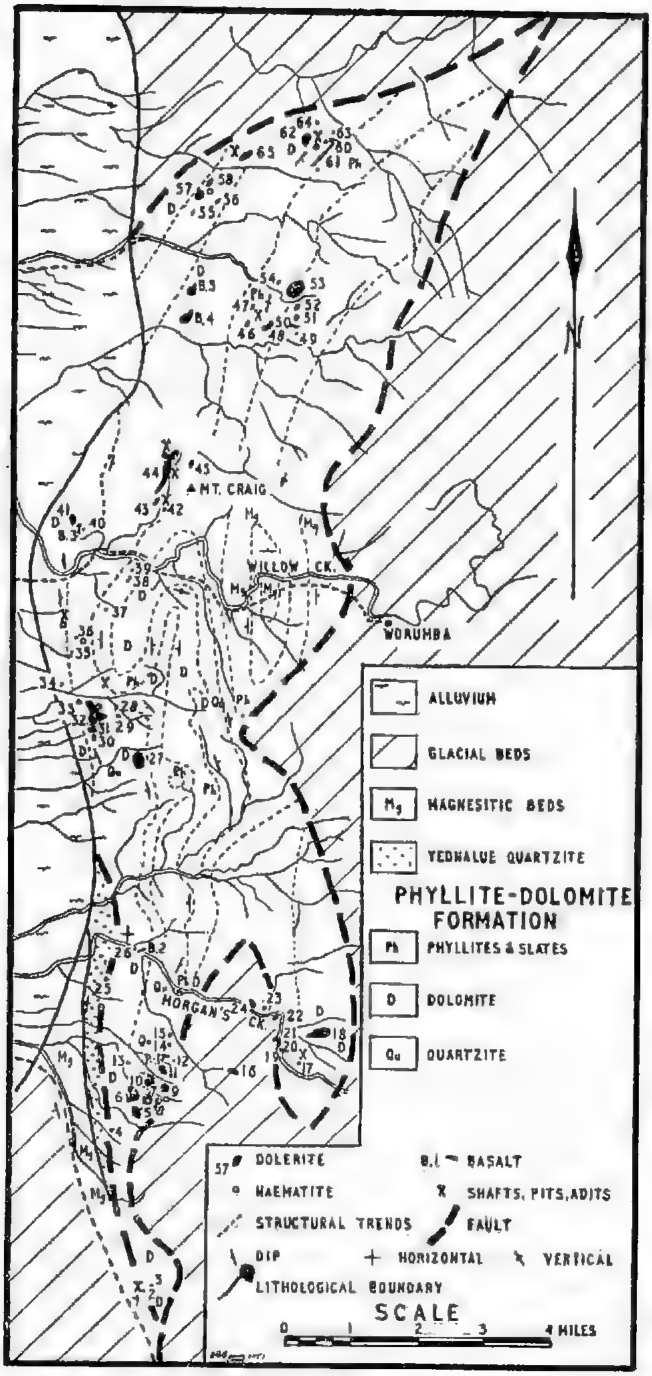

Fig. 1

Geological map illustrating the occurrence and distribution of the dolerites, etc., within the phyllite-dolomite fault block.

direction of major and minor fold axes and major and minor faults in the area around is north-south also.

Number 61 is the only body which shows any distinct tendency to dyke formation as it trends along the strike of the sediments, but is associated with several plug-like masses.

The occurrence of the basalts is interesting, as they all occur as apparently intrusive, irregularly circular masses and show no evidence in the field of being flows, either subaerial or submarine.

Number B. 1 is a body which is over 400 feet across the strike of the sediments, but only about 100 feet along it. It appears right in the middle of a group of dolerites and appears to merge into one intrusion, although this feature is most indefinite because of soil cover. The rock is amygdaloidal and moderately jointed.

Number B. 2 is a slightly elongated body which runs along the strike of the sediments in the bed of Morgans Creek. It outcrops only a few feet from a dolerite which shows obvious intrusive relations.

Number B.3 again occurs in the midst of a group of dolerite intrusions just north of Willow Creek. It is glassy and shows very strongly developed close jointing with the joint planes covered with epidote.

The Form of the Intrusions

The shapes of the igneous bodies are very irregular and tend towards subcircular or oval bodies with strongly elongated dykes or sills rather uncommon. The term "sill" might be applied to some elongated bodies which appear to have been intruded concordantly, but very often these are dykes which have forced the sediments immediately surrounding them into a vertical position parallel to the elongation of the igneous mass. The terms plug or stock are the only ones suitable to describe the vertical pipe-like bodies which are so common.

The form of the amygdaloidal or glassy basaltic bodies is frequently similar to that of the dolerites, thus suggesting that the basalts are intrusive. There is no doubt that interbedded flow basalts do occur at various places in the Flinders Ranges, but there is no evidence to support such an origin for the rocks in this area. Howard (1951) has described elongated outcrops of rather flatly dipping amygdaloidal basalt at Blinman. The author has seen these, and it is apparent that they have all the properties of flows, similar to those at Wooltana described by Mawson (1927). Basic pebbles have been found in beds overlying basalts by Mawson at Wooltana (1927) and Elatina (1949), and also at Enorama by Howard (1951), so that there is no doubt that there was at least some contemporaneous effusive activity in the northern Flinders Ranges. Howchin (1922) has referred to "volcanic necks" of basaltic material at Blinman and Wirrealpa and it seems likely that the intrusive amygdaloidal plugs were "feeder" pipes to true flows higher in the System. The close association in the field of extrusive and intrusive forms of the same magma has been repeatedly observed in rather mobile zones, and Marshall (1940) described an occurrence in the Carboniferous strata of the Midlands Counties of England. He noted that the criteria which normally indicate a flow may also be seen in a minor intrusion. The presence of (a) amygaloidal texture, (b) glassy or fine-grained edges, (c) lack of alteration of the sediments, may thus be found in both intrusive and extrusive igneous rocks as they apparently are in the basalts at Hawker.

The close association of intrusives and extrusives in several areas in the Flinders Ranges is probably due to the presence of a long-lived deep-seated weakness in the crust along which the rise of basic magma took place at widely spaced times.

The Mechanics of Intrusion

The basics occur singly or in small and large groups throughout the Mount Lofty-Flinders Ranges and the groups are usually located in an easily recognisable zone of tectonic activity. These zones of weakness frequently occur along or

near the axis of an anticline or dome, and this feature is seen at Mount Painter, Mount Stewart, Blinman, Enorama, Oraparinna and Worumba. Text figure 6 shows the distribution of the known basic intrusions which belong to this group and it may be seen that the fields are distributed along the axial portion of the geosyncline with the greater number of intrusions in the highly disturbed zones in the north. The extreme tectonic activity is shown in all areas by the occurrence of great masses of crush breccia as shown in pl. viii, fig. 1, and the dolerites frequently intrude the crush zones as shown by Sprigg (1949). Occasionally the igneous rock is itself brecciated by later movement. In the Worumba area we have the formation of an anticline which by continued thrust from the south-east became overturned. Large faults developed (the main one parallel to the axis of the fold) and a fault block was moved up many thousands of feet (at least 4,000 feet) into the axial zone, and this was followed by the intrusion of over 60 small bodies along the central portion, during probably a relaxational tensional phase after the folding.

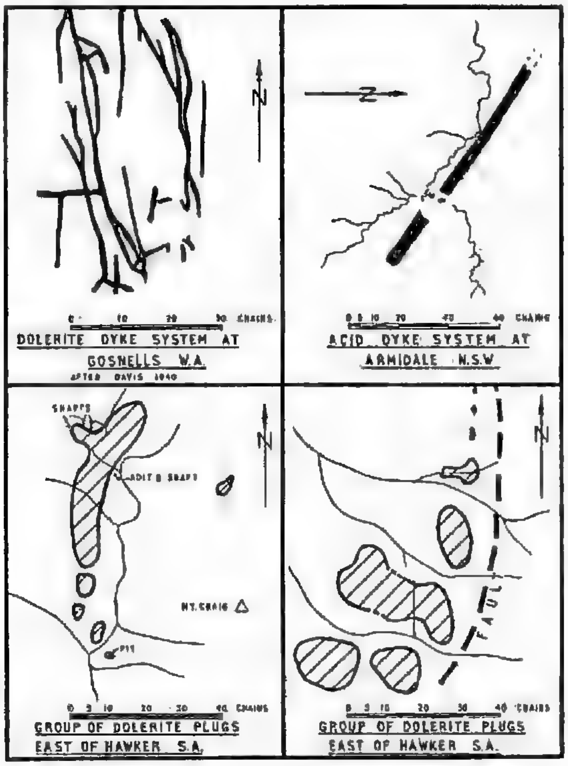

Fig. 2
Some minor intrusions illustrating varying degrees of regularity of conditions during intrusion.

Despite Howchin's frequent mention of dykes in the Flinders Ranges, the majority of the bodies are irregularly shaped plugs. Groups of plugs may occur along a line, but any regularity is usually lacking and this gives some idea of the conditions during intrusion when comparison is made with other minor intrusions. A dyke system of similar material and age from Western Australia has

been shown by Davis (1940) to possess a marked regularity as indicated in text figure 2. Here the dolerite was intruded into a massive granite and the form of the intrusion is due to a well-developed joint system in the country rock.

An example of varying regularity taken from Armidale in New South Wales is shown also in text figure 2. Here a large acid dyke (80 yards wide and over a mile long) breaks in the centre where there is a zone containing a number of small, irregularly shaped and distributed dykes with no relation to each other or to the main dyke. There is probably a large tensional fracture which controlled the formation of the major dyke but in the irregular, closely jointed central portion all uniformity is lost.

Thus a regular system of intrusions depends on regularity of the orogenic forces during intrusion and a regular response of the country rock to the forces. The response will depend on the homogeneity of the country rock and this will be reflected in a regular system of joints or larger fractures.

The zones of intrusion in the Flinders Ranges lie along major structural weaknesses, but the irregularity of form and distribution of the intrusions is caused primarily by the lack of homogeneity of the sediments and the consequential varying responses of beds of differing competency to orogenic forces. The forces themselves were not at all uniform in the small, highly contorted and crushed zones which suffered igneous intrusion.

THE PETROGRAPHY OF THE IGNEOUS ROCKS

Dolerites

In general the dolerites are dark green in colour with a fine to moderately coarse grain and textures varying between ophitic, intergranular and allotriomorphic. They originally consisted of augite and labradorite with accessory hornblende, ilmenite, apatite and quartz, but have typically suffered the secondary processes of uralitization and saussuritization. Olivine does not occur in this area but has been found as serpentine pseudomorphs in similar rocks in the Flinders Ranges.

The pyroxene was originally a member of the augite-pigeonite series and measurements on the universal stage gave optic axial angles from 15° to 50°. Quite often different crystals in the same rock gave a 2V range of 5° and in one specimen a range of 17° was obtained, indicating a strong variation in the lime content of the mineral, and this is a reflection of the strongly varying lime content of different dolerites. The pyroxene is very pale green or colourless and occasionally shows polysynthetic twinning. It is usually altered to uralitic actinolite which may be pale green and fibrous or somewhat better crystallized with colours from blue-green to greenish-brown.

The plagioclase was originally labradorite but only in a few cases was the unaltered mineral found, as saussuritization usually clouds the laths with epidote, zoisite or sericite with the simultaneous production of fresh albite.

A well-formed greenish-brown hornblende may be primary. Accessories are skeletal grids of ilmenite with leucoxene, apatite and quartz. Sphene is present in one specimen and riebeckite replaces the pyroxene in two others.

Rock [9098] from outcrop number 16 is a typical specimen. It is medium-grained with an irregular texture which is ophitic in some parts and hypidiomorphic to seriate in others. The rock consists chiefly of amphiboles with altered plagioclase, and a little pyroxene.

The pyroxene is a pale sub-calcic augite with an optic axial angle varying between 44° and 50°. There is abundant pale fibrous actinolite which is uralitic and forms pseudomorphs after the amphibole. A little hornblende, pleochroic from dark-brown to blue-green occurs as well formed crystals often intimately associated with ilmenite. The plagioclase remains as highly altered laths, some containing reasonably large flakes of white mica and others being clouded with a dense aggregate of zoisite and epidote. Only a little fresh regenerated albite is present together with a little biotite, skeletal grids of ilmenite with leucoxene and quite an appreciable amount of interstitial granophyric quartz.

Rock [9087] from outcrop 24 is a fine-grained greenish dolerite. It has an irregular texture, being intergranular and ophitic in parts. There is abundant amphibole and a little pyroxene with fresh labradorite and this is one of the few rocks in the area which contains primary plagioclase. It is colourless with moderately high relief and is twinned on combinations of the albite, Pericline and Carlsbad laws. Measurements on the universal stage showed it to be biaxially positive with an optic axial angle of 76° and a maximum extinction from the 010 of 30°, thus indicating an acid labradorite. The plagioclase shows all arrested stages in the alteration to ziosite, epidote and sericite. The pyroxene is a colourless sub-calcic augite with an optic axial angle of 47°. It is altered to a pale green-yellow actinolite which occurs as matted, fibrous masses. Subhedral crystals of brown to blue-green hornblende also are present. Accessories are ilmenite and slender needles of apatite.

Rock [9081] from outcrop 54 is an uncommon porphyritic dolerite, somewhat similar to Johannsen's (1941) "devonite". It has a porphyritic texture with a few large, highly altered laths of feldspar set in a medium-grained, intergranular groundmass. The phenocrysts are completely altered to mica or epidote and show a herringbone structure which is probably residual after original twinning. Smaller crystals are interlocking laths of labradorite (Ab_{42}) twinned on combinations of the albite, Pericline and Carlsbad laws, and these are fresh with a slight banding due to extremely fine inclusions. The pyroxene is colourless although sometimes faintly pleochroic and is surrounded by an indefinite brown amphibole. Epidote is abundant and a little micaceous haematite (?) and yellow chalcedony is present.

Rock [9100] from outcrop 32 is dark green and consists chiefly of partly uralitized sub-calcic augite ($2V = 47°$) which has an ophitic relation towards the highly altered plagioclase. A vein carrying a felted mass of fibrous amphibole cuts the rock. This amphibole is pleochroic with Z = bluish-green and thus differs from the uralitic variety common to the rest of the rock which is pleochroic from light to dark brown.

In rock [559] from outcrop number 43, the pyroxene varies in different crystals from a pigeonite ($2V = 30°$) to a sub-calcic augite ($2V = 47°$).

Rock [429 A] from outcrop 28 is medium-grained and of a bluish-green colour and is cut by veins of calcite up to ¼" wide. Distinct crystals of a blue amphibole and flakes of biotite are visible in the hand specimen. It has the typical doleritic intergranular texture, with plagioclase laths forming an interlocking mesh enclosing biotite and occasional large phenocrysts of blue amphibole with an ophitic relation. The plagioclase is albite and is comparatively fresh in appearance with comparatively few inclusions. Twinning is irregular and on the albite law with broad twins. The amphibole is pleochroic with X = light blue, Y = deep blue and Z = bronze to dark brown. It has a high optic axial angle and is probably negative. Extinction angles from the fibres

vary up to 7°. The mineral is a member of the crocidolite group which has a widely variable composition and is close to riebeckite. Biotite is very abundant as fresh brown flakes together with skeletal grids of rutile and a little calcite.

Basalts

The basalts are grey to black, fine-grained rocks with an amygdaloidal structure. The amygdales are usually filled with calcite and less often with siderite, epidote, quartz, chlorite or biotite. The groundmass may be hypidiomorphic granular, intergranular, ataxitic or glassy (now devitrified). The minerals composing the groundmass are indistinct but usually consist of albite, actinolite, chlorite, calcite, epidote and iron ore. Secondary alteration is invariably well advanced and no evidence of primary olivine, pyroxene or labradorite was found.

Rock [9091 C] from outcrop number B. 1 is light grey and fine-grained with numerous small amygdales about 3 to 4 mm. in diameter filled with calcite. It is holocrystalline with a partly intergranular groundmass. The rock consists chiefly of tiny interlocking albite laths (some well formed) with abundant calcite, green chlorite and a little brown biotite. Ilmenite with leucoxene is abundant as small ragged grains and euhedral crystals. The amygdales are rounded and filled with well-crystallized minerals which form concentric layers. The outer zone is rich in iron ore, followed by alternating layers of chlorite and biotite with a core of brownish siderite. The biotite and chlorite are frequently intergrown and merge into each other.

Rock [9093] is dark coloured and porphyritic with greasy green felspar phenocrysts and amygdales containing calcite and biotite set in a dense, black groundmass. It is hypocrystalline with the phenocrysts and amygdales set in a dense, black devitrified glassy groundmass. The plagioclase phenocrysts are frequently euhedral and lath-shaped and are composed of albite (Ab_{95}). They are well twinned and have abundant inclusions of epidote. Corrosion by the groundmass (mesostasis) is shown where the material has entered along cleavages and twin planes. Biotite occurs as red-brown flakes which are frequently bent. Calcite and chlorite also occur as small aggregates and sheafs. The amygdales are filled with calcite, biotite, epidote and pale-green actinolite.

The amygdaloidal appearance and high degree of mineralogical alternation has resulted in these basalts being referred to as spilitic. However, it is seen that there are considerable critical differences when the properties of the spilites and these basalts are compared. Spilites occur as submarine or subaerial flows or intrusives with pillow structure common but not universal. The vesicular parts have been converted to amygdales containing calcite, chlorite, chalcedony, quartz, agate, epidote and zeolites. The rocks are basic with occasional glassy material and typically contain albite, augite, chlorite, epidote, calcite and actinolite. Thus it may be seen that the basalts are spilitic in this sense. In addition both groups have altered dolerite, keratophyres and sodic granites associated with them. However, the chief distinguishing features of the spilites is the chemical composition and it is here that considerable differences are seen. The most critical point is the presence of large amounts of soda, and particularly a high Na_2O/K_2O ratio. From the analysis given by Mawson (1926, 1942) it is seen that the basalts contain less than 3·5% of Na_2O while K_2O may be present up to 2·76%, giving a soda-potash ratio much higher than the typical spilite. Also the FeO, CO_2, TiO_2, H_2O are not abnormally high as in most spilites and Al_2O_3 is not deficient. A keratophyre found by Howchin (1916) at Mount Remarkable does show definite spilitic characteristics with 6·1% of Na_2O and only 0·41% K_2O.

The Alteration of the Basic Rocks

The most typical feature of this group of dolerites is the almost invariable presence of secondary minerals. The rocks were composed of labradorite, augite (usually low in lime), occasionally olivine and accessory hornblende, ilmenite, apatite, biotite and quartz. The results of uralitization, saussuritization, chloritization, etc., are visible and there is secondary serpentine, albite, epidote, zoisite, actinolite, chlorite, sericite and leucoxene in practically all the dolerites and basalts. Some rocks are more altered than others and consequently all stages in the formation of the host of secondary minerals are seen.

The first alteration to take place is that of olivine to serpentine and iron ore. This was not found in the rocks of the Hawker area but was described by Benson (1909) at Blinman.

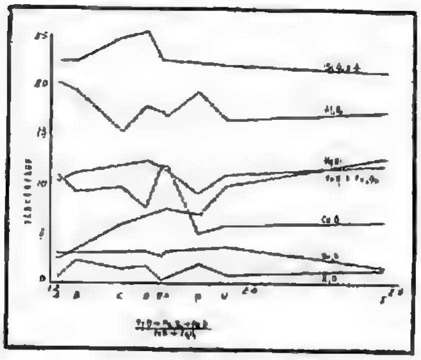

Fig. 3

A variation diagram showing the variation in chemical composition of eight members of this group.

Saussuritization is next to take place and in very few cases only is the original labradorite found. The alteration clouds the plagioclase laths with a mass of tiny granules of colourless zoisite or clinozoisite or yellow epidote. Occasionally secondary albite is sufficiently developed to be recognisable as fresh colourless crystals. The plagioclase breaks down into a mixture of albite and zoisite with epidote or actinolite entering the aggregate when iron or magnesia are available. The white mica which occasionally forms large flakes is rather more difficult to explain. The mica appears to be the potash variety sericite rather than the soda-paragonite and there are two possible sources of the potash. Vogt (1921) stated that normal plagioclase may contain up to 12% of orthoclase in solid solution and consequently the 2% or less of potash in these dolerites is probably present in the plagioclase (biotite is rarely present). Consequent breakdown of the plagioclase would precipitate the orthoclase as sericite with a concurrent freeing of excess potash. In some cases the potash appears to have entered the plagioclase from outside and altered it along cracks and cleavages. The potash concentrated in the late stage liquor may be assisted by that liberated by sericitization of orthoclase in causing sericitization of the plagioclase.

The pyroxene, which is an augite usually low in lime, alters peripherally to a pale fibrous actinolite which often entirely replaces the original mineral. The process presumably takes place after saussuritization as it is much more often partly arrested, although it appears to take place concurrently in many of the rocks. The actinolite in some cases is darker and shows distinct blue-green and blue pleochroic colours. In several cases (e.g., rock [9095]) a sodic amphibole near riebeckite in composition appears. The bluish tint in the actinolite is probably due to small amounts of soda (at least partly liberated by reaction with the plagioclase), although it may be caused by the presence of a little ferric iron.

An idiomorphic brown hornblende is often present and has been regarded here as secondary by Benson (1909). Williams (1890) regarded all such amphibole as secondary and Shand (1943) states that apparently primary hornblende is sometimes secondary after pyroxene. There is a conflict of opinion on the matter but in this case the hornblende is regarded as primary because of the size and perfection of the crystals and the lack of replacement evidence. The hornblende is typical of cooler and more hydrous conditions than the augite and probably crystallized at a moderately advanced stage in the consolidation of the rock.

Ilmenite is the common iron ore in these rocks and it occurs as skeletal grid-shaped masses. It alters commonly to leucoxene although it is frequently fringed with hornblende, suggesting that it contributed iron in the growth of that mineral. In one highly altered rock [9095] there are skeletal grids of rutile, suggesting a final stage in the breakdown of the ilmenite with loss of iron.

No attempt is made to list a series of hypothetical chemical reactions showing the processes of alteration as it seems likely that the changes were not separate reactions. The serpentinization of olivine involves the addition of silica and water, and takes place easily without concurrent reactions, but saussuritization and uralitization appear to be somewhat independent. All the reactions require additions of water and most also require silica.

The mineralogical changes of these rocks are similar to those found in a great many other places. As early as 1890, Williams attributed the alteration to stress and this has been confirmed with many greenschists, but in this case there is no evidence of shearing. Ophitic and intergranular textures are often perfectly preserved in the completely altered rocks and the secondary minerals are frequently well formed and in large crystals.

Harker (1939) indicated that uralitization and saussuritization may take place under conditions of thermal metamorphism, but there is no evidence of later igneous activity in this area.

Sutton and Watson (1951) and many others have shown similar mineralogical changes in the dolerites of the Scottish Highlands to be due to regional metamorphism, but there is little similarity in the regional conditions of the rocks under discussion. The dolerites are frequently found in zones which have been regionally metamorphosed and often may be shown to post-date the metamorphism, although in some areas the dolerites themselves are extensively altered.

Benson (1909) presumed that the changes were due to age and the overlying load of sediments, and Mawson (1923, 1926a, 1926b) has agreed with this. The long time that has elapsed since these magmas consolidated and their burial beneath a very thick series of subsequent strata would give opportunity for some readjustment in their mineral contents. There is, however, no evidence that age alone has any particular effect on rocks, as many Archean dolerites are quite fresh while some Tertiary dolerites show considerable alteration. Also, it is widely demonstrated that not only various members of a group, but also different parts of the same intrusion show differing degrees of alteration.

It has been generally accepted by Browne (1920, 1922), Cole and Glöe (1939), Davis (1940), Prider (1945, etc.) and others that the retrograde mineralogical changes are usually due to deuteric activity in a manner somewhat resembling the "autolysis theory" proposed by a number of workers to explain the alteration of spilites. There is much evidence to support the concept of alteration by late stage liquors during consolidation, although the basic reason why some dolerites should be fresh and others completely altered is obscure.

The secondary minerals are typically stable at moderately low temperatures, but are often well crystallized and fill veins across the rock, thus indicating a ready source of magmatic heat during the period of formation. The quartz frequently has crystallized after the uralitic actinolite, indicating that the final stage of consolidation of the magma took place after the secondary alteration.

There is a distinct relation between the order of crystallization of the minerals and the order of alteration, and as might be expected the earliest high-grade minerals to form are first to become unstable and be altered.

The order of the beginning of the formation of the primary and secondary minerals is probably as follows:—Olivine (with apatite and ilmenite), labradorite, augite, hornblende, serpentine, albite-epidote-zoisite-sericite-leucoxene, actinolite, biotite and riebeckite, quartz, calcite, chlorite-tourmaline.

There appears to have been a concentration of silica, water and alkalies during consolidation, and these attacked the anhydrous early-forming minerals forming the assemblage stable under hydrous low-grade conditions. The varying degrees of alteration of the dolerites then would presumably be due to the varying amounts of volatiles remaining in the consolidating rocks. A puzzling anomaly which becomes apparent is the lack of metamorphic effects by the dolerites. If the magma was so rich in volatiles as to cause deuteric attack of the earlier formed minerals, then it would be expected that these volatiles would be an active agent in altering the wall rock. Wahlstrom (1950) notes that a magma enclosed by impervious walls may have the volatiles concentrated and thus have abundant deuteric effects while a magma with porous wall rock may loose its volatiles and appear "dry". However, there is no evidence of a large amount of water retained in the consolidated dolerites which frequently show only 1% of total water, and there is no sign of metasomatism of the wall rock which would be expected if the volatiles were lost. Osbourne (1929) described a dolerite which contained the typical actinolite-epidote assemblage caused by deuteric activity but with a metasomatic aureole containing high-grade minerals. It seems apparent that the residual volatiles which cause the autometamorphism of the igneous rock are independent of the earlier released volatiles which cause metasomatism in the wall rock, and probably pass out of the dolerite in the very last stage of consolidation, being so cold that they do not affect the surrounding rocks. This may be the origin of the quartz veins occasionally seen in the country rock and the large white quartz "blows" such as that close to dolerite outcrop number 2.

In the large mass (number 44) just west of Mount Craim there is sufficient dolerite exposed in the hill to show a considerable vertical change in the rock. This is due partly to a gravitational differentiation process which is discussed later and partly due to another factor. The lower parts of the intrusion are richer in ferromagnesians and iron ore, while the upper part is richer in feldspar and quartz, and is also much more altered than the rock below. The top of the intrusion is a rock rich in albite, quartz and riebeckite. It is considered that during consolidation there was a two-way movement through the magma with the heavier, earlier-forming minerals sinking, and the lighter, later-consolidating part of the magma rising. This latter portion would be rich in silica and alkalies and would hydrothermally alter the previously consolidated upper part of the intrusion. Thus in a few extreme cases where rocks rich in riebeckite, albite, biotite, sphene, apatite, tourmaline, rutile and calcite occur, there has probably been hydrothermal as well as deuteric activity.

An examination of all available chemical analyses shows no apparent relation between the chemical composition and degree of alteration, apart from the extreme cases mentioned above where hydrothermal action has taken place. The late stage fluids responsible for the formation of the secondary minerals would

be rich in silica, alkalies and water and the dolerites usually contain about 49% SiO_2, 3% Na_2O, 2% K_2O and 1% H_2O. There is no significant variation in these components between unaltered rocks and those in which no original pyroxene, plagioclase or olivine is visible. Thus if there was an excess of these constituents then they must have been quietly lost to the wall rock. The differing degree of alteration of the dolerites may possibly be related to degree of differentiation and consequently to the distance from the roof of the intrusion, so that the apparent difference in alteration between the igneous masses may depend on the degree of erosion.

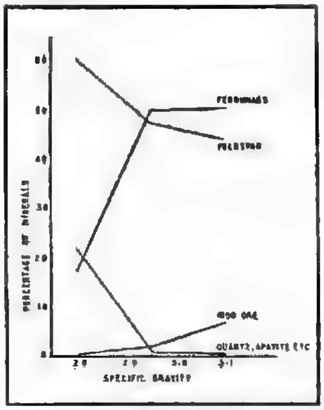

Fig. 4

A modal variation diagram showing the mineralogical differences between three differentiates.

Chemical Composition of the Basic Rocks

A variation diagram, text figure 4, illustrates nine analyses of dolerites and basalts from the Flinders Ranges.

A. Dolerite from Rosetta Head (anal. Yeates), Browne (1920).
B. Dolerite from Blinman (anal. Benson), Benson (1909).
C. Dolerite from Blinman (anal. Benson), Benson (1909).
D. Dolerite from Wirrealpa (anal. Robinson), Mawson (——).
E. Dolerite from Broken Hill (anal. Stone), Mawson (1926a).
F. Basalt from Wooltana (anal. Chapman), Mawson (1926).
G. Dolerite from Wooltana (anal. Alderman), Mawson (1926).
H. Dolerite from Wooltana (anal. Alderman), Mawson (1926).
I. Dolerite from Blinman (anal. Howard), Howard (1951).

Thus it can be seen that there is a reasonably wide variation in composition, even in rocks which are closely related in the field. The lime and potash are particularly variable. Rocks in Northern and Western Australia which are presumed to be members of the same province usually contain about 1% less soda.

There appears to be a tectonic control of the chemical and mineralogical composition of the rocks with normal basic types in the stable portions of the shield in the western and northern parts of Australia and rocks approaching the spilites in the moderately unstable Adelaide System miogeosyncline with true spilites in the mobile eugeosyncline to the east.

Differentiation

Processes of differentiation appear to have taken place both on a large and small scale during the lower Palaeozoic period of intrusion. The minor differentiation effects appear to be intimately associated with the deuteric and hydrothermal activity during crystallization. The dolerite body, number 44, illustrates this. A range of rocks from the hill which is several hundred feet high shows a decrease in specific gravity from the base to the top and an accompanying lightening of colour as the melanocratic constituents decrease and the leucocratic proportion becomes greater.

A variation diagram, text figure 4, illustrates the mineralogical differences with relation to the specific gravity of three specimens taken at the base, half way up, and the top of the hill, and text figure 5 shows the differences in texture under the microscope.

Rock specimen [9085], taken as low as possible from the intrusion is a dark-coloured, coarse-grained dolerite with a specific gravity of 3·1. It has a texture which is chiefly hypidiomorphic with variations to intergranular and ophitic and consists of 49% of amphiboles, 44% of plagioclase with abundant (7%) iron ore. Pale fibrous uralitic actinolite forms pseudomorphs after pyroxene and shows polysomatic structure together with some occasional herring-bone structure which is probably residual after simple twinning in the pyroxene.

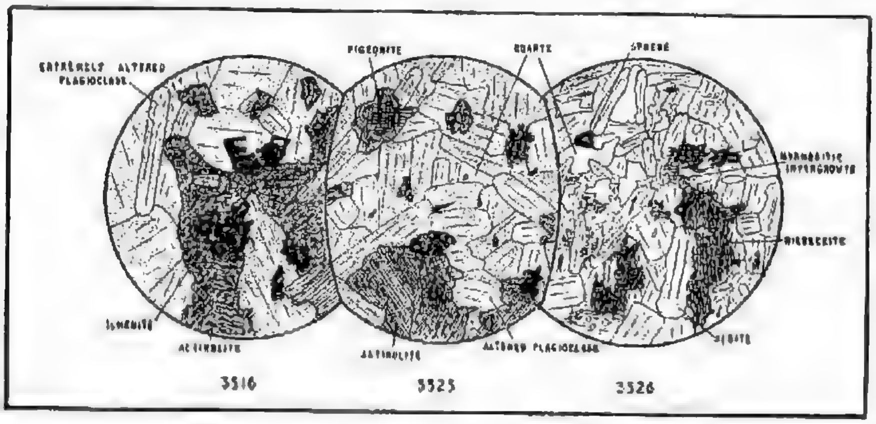

Fig. 5
Microsketches showing the mineralogical and textural variation between three differentiates.

Idioblastic hornblende is also present and is pleochroic from yellow to brown with a bluish-green colour sometimes appearing. The original feldspar has been completely changed to zoisite or sericite. The plagioclase now present is pure albite and is quite fresh and irregularly twinned. A small quantity of quartz is present as graphic and myrmekitic intergrowths with the albite. Iron ore is fairly abundant as skeletal grids and granules and appears to be partly micaceous haemetite as well as ilmenite. It is almost invariably surrounded by a growth of fresh brown hornblende and in one instance contains a little brown siderite.

A specimen [9094] from half way up the hill is a light greenish-grey rock, medium-grained and with a specific gravity of 2·95. It is holocrystalline with an irregular texture and grain-size. The rock appears to have originally had an intergranular texture which has been obscured by the subsequent mineralogical changes. The rock contains 52% of ferromagnesians and 47% of plagioclase. There is both primary pyroxene and secondary amphibole present. The pyroxene is a colourless pigeonite with an optic axial angle of 15° and occasionally displays polysynthetic twinning. The amphibole is a very pale actinolite with brilliant polarization colours. There is a very little brown hornblende also present. The plagioclase has been completely altered to zoisite and the original laths have been replaced by aggregates of tiny granules polarising in anomalous blues. Some fresh albite is present, sometimes as intergrowths with quartz. A few scattered skeletal grids of iron ore occur with secondary leucoxene. There is also a little chlorite, apatite and sphene present.

Specimen [S 43] from the top of the intrusion is a light-coloured, medium-grained rock with a specific gravity of 2·8 and resembling a keratophyre. It shows the characteristic intergranular texture with interlocking feldspar laths enclosing amphibole crystals. Plagioclase is most abundant (58%) as large subhedral laths. It is a pure albite and is comparatively fresh with abundant tiny inclusions. Twinning in very irregular and is chiefly on the Carlsbad law with lesser albite and Pericline twinning giving a "checker-board" appearance. Myrmekitic intergrowths with quartz are very common, and the quartz shows good replacement textures in many parts. There is only 17% of amphibole and this occurs as irregular, anhedral, fibrous masses which are pleochroic from X = dark blue-black, Y and Z bronze and has a very low extinction angle, thus resembling riebeckite. Also present are apatite 4%, sphene 6%, and a little haematite, epidote and calcite.

There is a concentration of minerals lighter in colour and weight in the upper part of the intrusion and these are also typical of the later stages of crystallization. There is a complete lack of primary olivine, labradorite or pyroxene in the top of the body and this part is more altered than the base. The differentiation appears to have been primarily due to a settling of the early-forming, heavy ferric minerals leaving a magma of lower specific gravity and containing a higher proportion of silica, alkalies and titania. The primary labradorite and augite in the upper part were completely replaced by secondary minerals due to deuteric attack and there was probably continuous enrichment in the lighter constituents rising from below during consolidation, thus causing hydrothermal alteration of the crystallized minerals. Consequently the closed system with its deuteric activity, which is typical of the dolerites, becomes an open system and hydrothermal changes resulted in the formation of the extreme alkaline rocks which are sometimes found. These rocks contain sodic amphibole, albite, quartz, calcite, biotite, sphene or rutile and are typified by specimen [S 29a]. This is probably the explanation of the origin of a dolerite described by Wymond and Wilson associated with crocidolite near Robertstown (1951). That dolerite contains a sodic amphibole and tourmaline.

The hydrothermal enrichment of the upper zone occasionally continued into the roof rock and produced a metasomatic zone rich in soda amphibole, albite, sphene and haematite.

Apart from the few rocks of alkaline composition and doleritic texture, which may be satisfactorily explained, there also occur isolated occurrences of small rather acid bodies in other areas. Howchin (1916) described an association of aplitic and keratophyric types with the dolerites of Mount Remarkable.

METAMORPHISM

Within the fault block some rocks show evidence of low-grade regional metamorphism, while practically none show any effects of thermal metamorphism. It would be expected that the impure dolomites and calcareous phyllites would respond easily to temperature changes and be markedly affected by metamorphism. A few phyllites are found which are recrystallized and reveal the production of biotite, chlorite and talc indicative of the biotite-chlorite sub-facies of the greenschist facies of Turner (1946). The regionally metamorphosed rocks are rather sporadic in their occurrence and are not widely developed.

The basic intrusions occur in large numbers in various areas in the Flinders Ranges where regional metamorphism also is evident. This is most strongly shown about domes and anticlines at Mount Painter and Freeling Heights in the extreme north, and progressively less to the south at Mount Stewart, Blinman, Enorama, Oraparinna and Worumba. There appears to be a general

restriction of the more abundant basic rocks and the highest grade of metamorphism to zones of weakness associated with anticlinal axes.

Apart from the phyllites, there is a little more evidence of regional metamorphism in its dying stages in the area concerned. About a mile north of Yednalue there is a large outcrop of an irregular, coarsely crystalline rock composed chiefly of quartz and dolomite with microscopic tourmaline and rutile, and it should be noted that titanium and boron metasomatism is typical of the lower Palaeozoic regional metamorphism province. There is a distinct possibility, however, that this rock may be the hydrothermally altered roof of a dolerite intrusion.

As the intrusion of basic magma has frequently taken place into pure dolomites, it is of interest to compare the limited contact effects here with the striking metamorphism in other unrelated areas.

The dolerite mass, outcrop number 18, near Morgan's well, is over a quarter of a mile in diameter and quite coarsely grained, but does not show any appreciable contact metamorphism.

Alteration was found in one place only and even then was limited to a few square feet of outcrop near dolerite outcrop number 44. A small mass of iron-rich skarn occurs in the impure dolomite. The altered rock [9067 and S 43], varies from light-yellow to dark-brown in colour and is very irregular in grain and texture.

The hand specimen shows aggregates of fibrous amphibole, blades and granules of haematite, and a few apophyses filled with yellow dolomite crystals. The minerals range in size from haematite blades 2 mm. long to amphibole fibres less than 0·1 mm. in length. The rock is chiefly dolomitic with haematite, feldspar and fibrous amphibole together with a little sphene, grossular, apatite, phlogopite, chlorite and rutile. There are segregations rich in various minerals, particularly haematite. The feldspar occurs as xenoblastic, clouded crystals occasionally showing poorly-defined twinning; it is probably oligoclase-andesine. Amphibole is present probably in two varieties, but the fibres are too small to permit optical properties to be determined. The fibres are pleochroic from blue to mauve or blue to yellow with low extinction angles and moderate birefringence and is presumably soda-rich. The rock indicates metasomatism by fluids rich in iron, soda, titania and silica by the dolerite.

It is seen that in the only case of appreciable alteration by the dolerite, metasomatism was the prime factor in producing changes, and it is considered that the action of "fluids" from the basic rock is of far greater importance in producing metamorphic effects than heat. Tilley and Harwood (1931) found larnite, spurrite, gehlenite, etc., produced in chalk by a dolerite intrusion only 300 yards by 200 yards in size, and the effects were attributed to metasomatism as well as metamorphism.

Osbourne (1929), Chapman (1950), Holmes and Harwood (1928) have described contact effects of dolerite dykes and sills where a typical high-grade assemblage of minerals was produced, and on each case a process involving metasomatism was suggested. It is odd that the dolerites which are typified by late-stage alteration products due to a concentration of active magma constituents should show the lack of metamorphism usually attributed to a "dry" magma.

Howchin, Prider, and Mawson have noted the lack of metamorphism of the country rock by the dolerites. The occurrence of a bi-mica gneiss and garnet rock in the contact zone of some Blinman dolerites described by Howard (1951) is possibly due to the combined action of regional and thermal metamorphism.

THE ECONOMIC IMPORTANCE OF THE BASIC INTRUSIONS

There is additional evidence in this area to support the generally accepted conviction that the dolerites are genetically related to mineralization particularly of copper and less of silver-lead. Text figure 1 shows a very close relationship in the field of seven groups of disused workings with the basic igneous rocks. The workings range from shallow pits to quite deep shafts and there is an adit more than 300 feet long in towards the dolerite outcrop number 44. This latter intrusion has four shafts along its contact with the country rock, as shown by text figure 2. The dump shows ore containing bornite, chalcopyrite and pyrite with a little azurite and malachite, as replacement deposits in an impure and brecciated dolomite. Near dolerite outcrop number 41 there is a brownish, compact indurated argillite containing abundant limonite pseudomorphs after euhedral crystals of pyrites. The rock shows no sign of mineralogical changes due to metamorphism. It seems to be a general feature that copper mineralization occurs close to the igneous rocks and is most common in dolomites and brecciated zones.

The occurrence of masses of haematite is also a notable feature associated with the dolerites and the positions of five bodies in indicated in text figure 1. The haematite occurs in large masses of solid mineral or as small veins of highly micaceous specularite which are usually associated with crushing. The larger massive bodies are pipelike replacement deposits and have usually been investigated to discover whether they form "ironstone caps" to mineral deposits, but without any success. Small amounts of bladed and granular haematite occur in a patch of skarn rock in contact with the dolerite of outcrop number 44.

A little blue asbestos (crocidolite) occurs in an outcrop, a highly-altered dolerite (number 28), but does not appear to be economically important.

There are deposits of barytes in the area but these do not appear to be related to the igneous rocks, although barytes has been found as a gangue mineral in copper deposits associated with dolerite.

The relation between the igneous rocks and mineral deposits has been repeatedly mentioned in reports from the Flinders Ranges and even further afield.

Outside of South Australia the association of copper minerals and these Proterozoic-Palaeozoic dolerites has been reasonably established. Prider (1945), Matheson and Tiechert (1945) and Browne (1949) in particular have pointed out the occurrence of copper, silver-lead and gold minerals with the dolerites of Western Australia and the Northern Territory.

The deposits show the mineralogical association, textures and field occurrence which are typical of mesothermal contact ore bodies formed by pneumatolytic action in the zone of alteration of an igneous intrusion.

RELATED ROCKS

During work on the basic rocks east of Hawker the author was struck with the similarities, even down to minute mineralogical details, between these and other rocks seen in the Mount Lofty and Flinders Ranges. Other occurrences have been inspected and a further resemblance was noticed in the field relations. An examination of the literature and of specimens and slides from the museum of the Adelaide University has revealed a group of basic rocks (dolerites and basalts) which are so distinct in their petrological nature that there seems little doubt that they form a distinct province. The rocks occur throughout Southern, Northern and Western Australia in the area which has been called "the shield" and form flows and intrusions ranging from Early Upper Proterozoic to Middle Cambrian in age and lying among Adelaide System, Nullagine, Cambrian and

Archean rocks. David (1950) has grouped this suite in his Cambrian igneous rocks. The localities in the Mount Lofty-Flinders Ranges area, where rocks of this group occur, are indicated on text figure 3.

Details of all these occurrences would be too extensive to include in this contribution, but the map presented gives a good idea of their distribution. In addition to the basic rocks in the Mount Lofty-Flinders Range area there are many others further afield which should be included in this province. The Western Australian geological record is replete with accounts of similar magma types intruded and extruded in late Precambrian and early Palaeozoic time. These could well be included with the South Australian examples in an overall discussion on subcrustal magmas of that period. However, any such elaboration must be reserved for a future occasion.

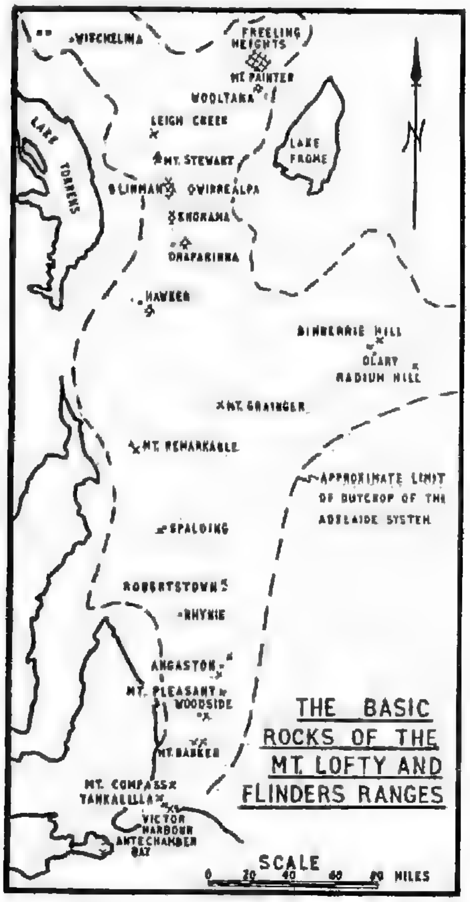

Fig. 6

Map showing the distribution of the known occurrences of basic rocks of this group.

The Age of the Basic Activity

The actual age of the basic rocks is difficult to establish, but there seems no doubt that vulcanism began early in Adelaidean times and culminated in the Early Palaeozoic. Basalts are found below the Sturt Tillite at Wooltana and above at Blinman and flows occur extensively through the Nullagine of Western Australia. Basalts form the base of the Cambrian in the north and north-west of Australia. Dolerites may have been intruded before sedimentation ceased but it is presumed that the majority were emplaced at a time related to the period of folding of the

Upper Proterozoic and Lower Cambrian strata in the Adelaidean Geosyncline. This occurred in the interval between the fossiliferous Middle Cambrian and the Permian tillite and the exact date is not known. The folding was probably during David's (1950) Tyennan orogeny, and the igneous activity associated is possibly contemporaneous with the Heathcotian lavas of Victoria, the Cambrian spilites of King Island and Tasmania and the Brisbane greenstones.

The dolerites were intruded both before and after the period of regional metamorphism and acid intrusion in the Lower Palaeozoic. Dolerites which are metamorphosed or intruded by acid rocks are found at Encounter Bay, Woodside and Mount Remarkable, although the majority appear to be later than both the folding and the metamorphism.

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Fig. 1
A typical tectonic or crush breccia near a dolerite intrusion. The more brittle parts of the phyllite have fractured while the incompetent groundmass has flowed and cemented the fragments.

Fig. 2
A view of dolerite outcrop number 32 from the south-east. It appears as the high conical hill just left of the centre. The rolling hills in the foreground are composed of the phyllite-dolomite formation, while the Druids, Chace and Elders Ranges (of Pound Sandstone) appear in the background.

Fig. 3
A closer view of dolerite outcrop number 32, taken from the north-west. The hills to the centre and left are composed of dolerite, while limestone dipping to the west appears on the right.

Fig. 4
Rounded boulders of coarse dolerite outcropping on the southern ridge of outcrop number 44.

THE POSTORBITAL WALL – A COMPARITIVE AND ETHNOLOGICAL STUDY

BY M. R. HONE

Summary

The paper surveys the formation of the posterior wall of the orbit on a comparative basis. The wall is developed essentially by the extension of bony flanges from the frontal, sphenoid and zygomatic bones. The maxilla may take part. With growth of the wall communication between the orbit and the temporal and infratemporal regions becomes restricted to a narrow fissure. The wall is most complete and the fissure narrowest in the Cercopithecidae, the orang and the gorilla. The gibbon and the chimpanzee have wider fissures. The human condition resembles that of the chimpanzee. Human skulls show a wide range of variation in shape and size of the fissure. Statistical analysis discloses no ethnological significance in this.

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By M. R. Hone *

[Read 8 November 1951]

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INTRODUCTION

The bones and general arrangement of the orbit in various orders have been described by many authors, e.g., Duckworth (1904), Whitnall (1921), Martin (1928), Le Gros Clark (1934). This paper presents a general survey of the formation and closure of the postorbital wall, followed by more detailed study of the human condition to determine whether or not the bony pattern has any ethnological significance. The animals discussed in the first part of this paper have been chosen less to suggest a close evolutionary pattern than as affording a good example of each stage of development.

ONTOGENESIS

Submammalia

In fishes, the orbit is composed of a prefontal, postfrontal, frontal, and a varying number of bones on the ventral border grouped as lacrimals (Owen, 1868). Medially, the base of the eye is separated from its partner by the presphenoid.

In the frog the eyes face laterally and are surrounded by the parietal, frontal, sphenoid, ethmoid, nasal and maxilla. There is no bone posteriorly.

In reptiles the orbital margin is composed of the following five bones: jugal, postorbital, frontal, lacrimal, and maxilla. An example is seen in the skull of *Trachysaurus rugosus* (fig. 1), which shows a jugal bone laterally, a postorbital and frontal above, a lacrimal and part of the maxilla in front, and the rest of the maxilla below. Separation of the eyes is as in fishes. The eye still faces laterally. The medial and posterior surfaces of the eye have no bony protection but are adequately supported by muscle.

In birds, although the eye still faces laterally, there is usually greater bony protection. An interorbital septum, either complete or incomplete has developed out of the prefrontals, while the lacrimals and the postorbitals afford additional support.

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Mammalia

The skulls examined were:

Rodentia			
Suborder Lagomorpha			
Family Leporidae	....	*Oryctolagus cuniculus*	1
Carnivora			
Family Canidae	....	*Vulpes vulpes*	1
Family Felidae	....	*Felis cattus*	1
Primates			
Suborder Prosimii	....	*Lemur varius*	1
Suborder Anthropoidea	....		
Superfamily Cercopithecidae	....	*Papio babuin*	1
		Cynocephalus sp.	1
		Cercopithecus tantalus	1
		Macacus rhesus	4
		Macacus fascicularis	1
Superfamily Hominoidea	....		
Family Pongidae	....	*Hylobates*	1
		Simia	1
		Gorilla	1
		Anthropithecus	3

The Rabbit (fig. 2)

The cranial wall of the orbit is formed by two upward projections of the basi-cranium, namely, the orbito-sphenoid (anterior or lesser wing) and the ali-sphenoid (posterior or greater wing). The remainder is formed of membrane bone, the frontal and jugal part of the squamosal (Bensley, 1918). The apex of the orbital cavity extends practically to the midline. Above, the frontal bone slopes laterally and upwards; below, the sphenoids slope laterally and downwards. The cranium bulges laterally behind so that the eye is given adequate protection at the back by the frontal and the temporal bones and the frontal carries a small posterior superior orbital process above.

The Fox (fig. 3)

The bony orbit is formed by the frontal, lacrimal, jugal, and ali- and orbito-sphenoid. The apex of the orbital cavity does not extend as far towards the midline as in the rabbit, but the orbit is just as deep relatively because the jugals stand out further from the side of the skull, and they run straight on to the sides of a much rounder cranium. Behind the orbit the cranial wall, composed of sphenoid and frontal, is so far removed from the eye that it gives little protection or support. Hence the posterior superior orbital process is larger and there is a distinct inferior process on the jugal as well. The larger post-orbital processes of the frontal and jugal, combined with the upward direction of the jugal bone as it runs backwards, almost complete the fourth side of the bony margin round the orbit.

The direction of the orbit changes with the species. In the fox the axis points more anteriorly than in the rabbit although its general direction is still lateral. But in short-faced dogs such as the pekingese the eyes have moved more towards the front (Weidenreich, 1941). However, there does not appear to be any compensatory enlargement of the posterior orbital processes in this condition.

The Cat (fig. 4)

The bony walls of the orbit are generally similar to those in the dog but the skull is shorter and wider and the orbit faces more anteriorly. Thus, there is no longer a frontal wall as in preceding specimens. The greater width of the cranium has pushed the jugal process of the temporal bone later-

ally and so the lateral wall of the orbit (the jugal bone) is also displaced laterally. The cranial wall still forms the posterior orbital wall but, as in the dog, because of the frontal position of the orbit, gives little protection or support to the orbital contents. The posterior orbital processes are much better developed than in the dog.

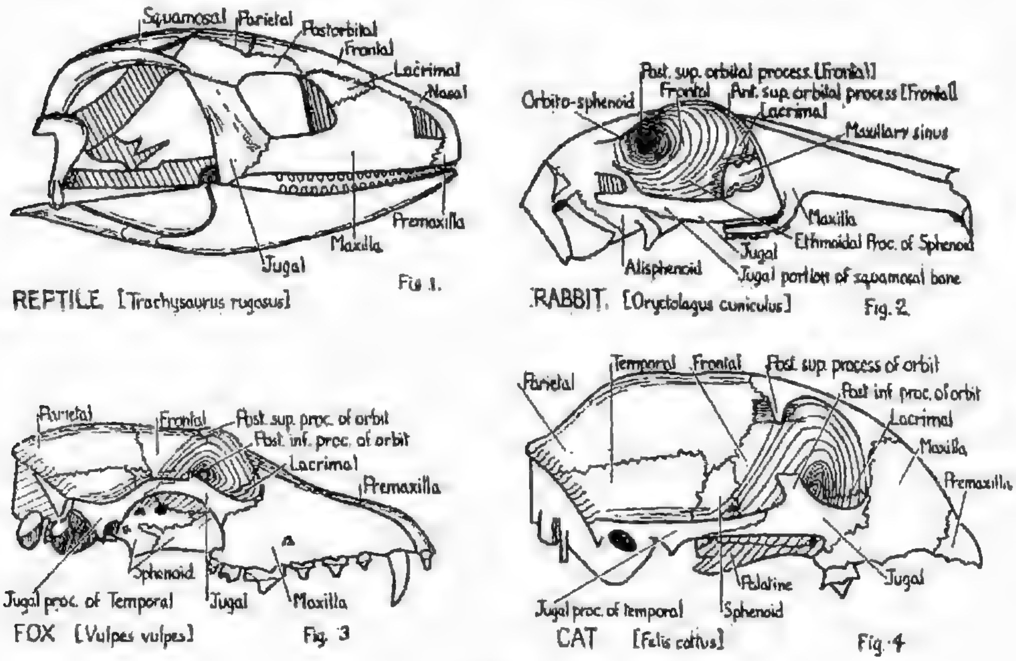

Fig. 1 - 4

THE LEMUR (fig. 5)

The suture lines were fused in the skull available but the boundaries of most of the bones were distinguishable. The eyes are directed almost to the front, the post-orbital bar is complete and there is just a hint of the posterior orbital wall forming. The jugal bone runs up the posterior side of the orbital bar and so forms the beginning of the posterior wall. The frontal helps by providing a roof for the orbit, which extends laterally and slightly posteriorly as well. Medially the orbit is closed behind by the cranial wall but laterally the orbit opens freely into the temporal fossa.

Mention must be made here of a specimen of the flying "lemur" of Malaya (*Galeopithecus volans*) in the Adelaide Museum. This is not a true lemur but it shows an interesting transitional stage. The postorbital bar is not quite complete, but the gap is filled by a bar of cartilage.

THE TARSIER (fig. 6)

Unfortunately, no skull of the tarsier was available, but there are many good accounts of the osteology of *Tarsius spectrum*.

The postorbital bar is completed by the union of processes from the jugal and frontal (Wood Jones, 1929). Above, the frontal sends a flange posteriorly to meet the parietal; below, the jugal meets the sphenoid in a similar manner, but leaving a gap underneath. This gap is bordered by the sphenoid, palatine and maxilla and represents the inferior orbital fissure of other primates.

THE MACAQUES

Two species were examined, one adult *Macacus fascicularis,* and two adult and two young specimens of *Macacus rhesus.* The posterior wall is thick and well formed. The inferior orbital fissure is small and in most cases the sphenoid overlaps the maxilla in a curved manner so that the opening practically faces caudally.

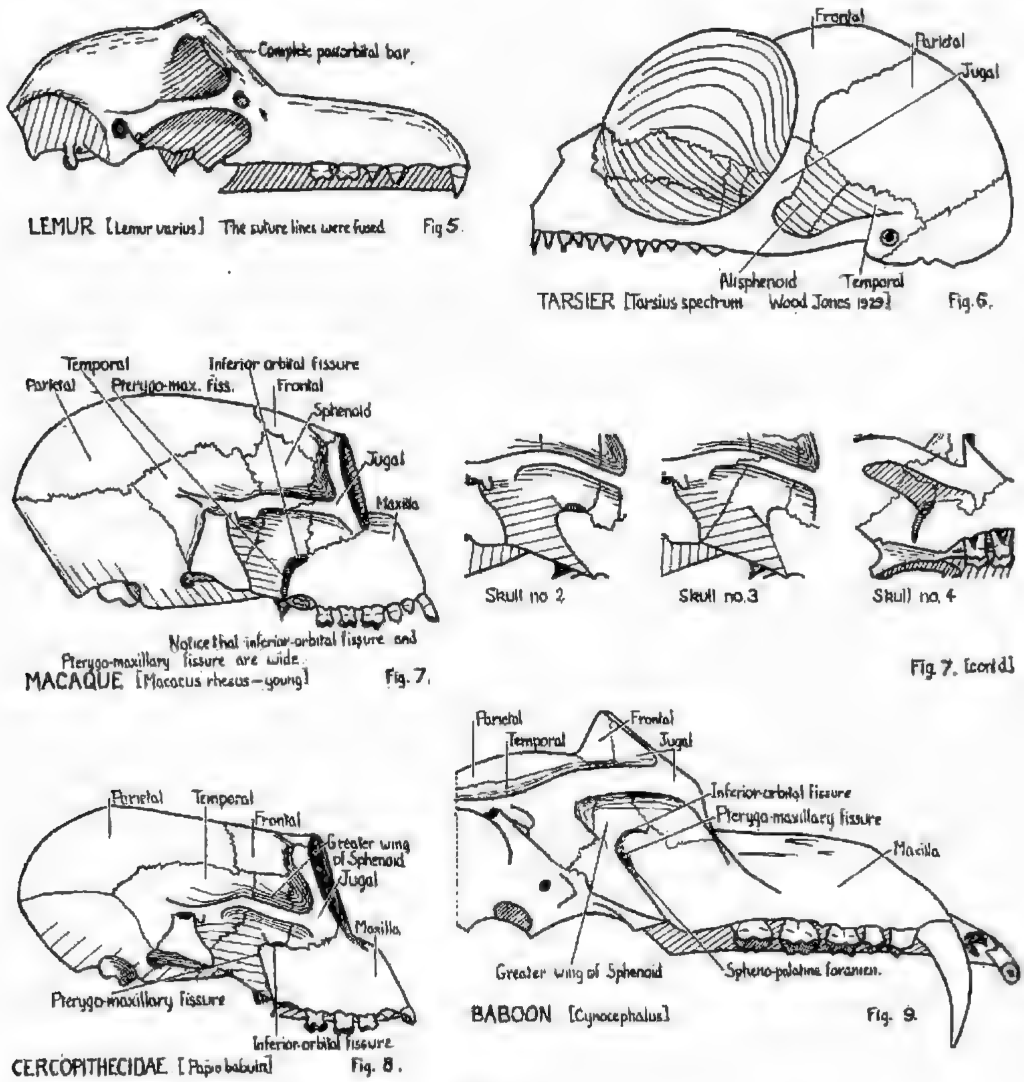

Fig. 5 - 9

MACACUS FASCICULARIS (fig. 7, skull No. 4)

In this specimen, three bones form the boundaries of the inferior orbital fissure: the greater wing of the sphenoid, the jugal and the maxilla. The fissure is directed caudally; the sphenoid forms the lateral border and the maxilla the medial border. The jugal forms the tip, being almost excluded by the other two bones. The frontal bone forms the main part of the postorbital wall, with the sphenoid and jugal forming the basal and lateral portions respectively.

Macacus rhesus (fig. 7, skulls No. 1, 2 and 3)

The arrangement of the bones round the inferior orbital fissure is the same as in the above specimen, but the proportions of the postorbital bones differ. The frontal takes a very small part, most of the wall being formed by the sphenoid and the jugal.

In two young macaques the inferior orbital fissure was large and the pterygo-maxillary fissure wide. This shows a less developed form of the postorbital wall.

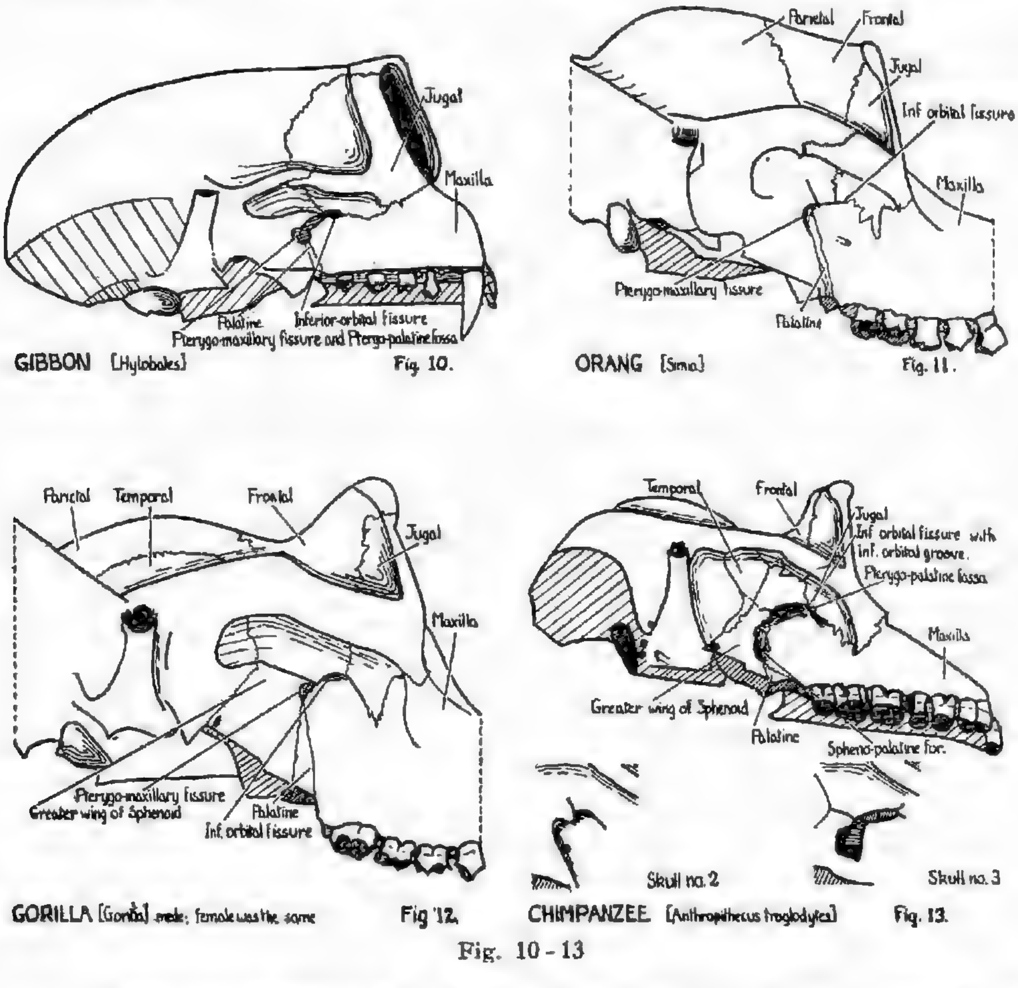

Fig. 10 - 13

The remaining examples of the Cercopithecidae (fig. 8) are similar to the macaques, except in *Cynocephalus* (fig. 9). Here the posterior wall is complete and the inferior orbital fissure is not visible from the lateral aspect. The bones that form the borders of the fissure are the same as in the macaques but the temporal bone runs forward to make contact with the jugal bone, separating the frontal from the sphenoid.

Gibbon (fig. 10)

Unfortunately, in the specimen available, the suture lines were mainly obliterated but the zygomatico-frontal, zygomatico-parietal, zygomatico-maxillary, and palato-maxillary sutures were detectable. The boundaries

of the inferior orbital fissure are formed by the sphenoid and jugal above and laterally, the maxilla and palatine below and medially, and the sphenoid and palatine behind. The inferior orbital fissure is quite wide, especially at the posterior end.

The postorbital wall is formed mainly by the jugal bone, with the greater wing of the sphenoid forming the posterior portion and the frontal the superior portion.

Orang (fig. 11)

Once again, most of the sutures had fused, but it was possible to tell that the walls of the inferior orbital fissure are formed by the same bones as in the gibbon. However, the palatine plays only a small part in forming the lower and posterior wall as compared with the condition in the gibbon. The fissure is a narrow slit.

The postorbital wall is composed of the jugal, the greater wing of the sphenoid and the frontal. It is doubtful whether the maxilla could be considered to take part.

The Gorilla (fig. 12)

Two specimens of gorilla were examined, a male and a female. Although the female skull was much smaller than the male, the postorbital wall was exactly the same.

The inferior orbital fissure is at the junction of the floor and the lateral wall of the orbit. The boundaries are: the greater wing of the sphenoid above and behind, the jugal in front, and the maxilla and palatine below and medially. The greater wing of the sphenoid has well overlapped the border of the maxilla, giving the inferior orbital fissure a downwards direction. This condition was more marked in the gorilla than in the orang. The overlapping sphenoid close to the maxilla reduces the fissure to a narrow slit.

The Chimpanzee (fig. 13)

Three chimpanzees were examined and they showed considerable differences.

In all three the postorbital wall is formed by the frontal above, the jugal in front, and the greater wing of the sphenoid behind.

Two skulls had wide inferior orbital fissures, unobstructed by a sphenoidal flange, and the inferior orbital grooves were plainly visible. The pterygo-maxillary fissure was wide and the palatine could be seen through it in the floor of the pterygo-palatine fossa. The spheno-palatine foramen could readily be seen from the lateral side. In the third specimen the inferior orbital fissure was also wide but the greater wing of the sphenoid overlapped the maxilla to produce a condition superficially resembling that found in the gorilla. The pterygo-maxillary fissure was the same as in the other specimens.

It is interesting to note that in the Family Simiidae, the inferior orbital fissure has moved downwards and occupies the infero-lateral angle of the orbit. The maxilla forms the lower border of the fissure. This is different from all observed specimens of the Cercopithecidae where the inferior orbital fissure is in the middle or lower portion of the postorbital wall, hence allowing the maxilla to form part of the postorbital wall.

Man

The development of the postorbital wall has been dealt with in the first part of this paper. The gorilla and the orang betray more marked differentiation in this part than does man whose inferior orbital and pterygo-maxillary fissures are relatively large as in the chimpanzee. Martin (1928) gives the following areas for comparison in size:

Anthropoids	4 - 7 sq. mm.
Europeans	58 - 61 „ „

The object here is to deal with the postorbital wall in man and to determine—

(a) if there are any variations that may distinguish different ethnological groups.
(b) the form of these variations and the reason, if any, for their occurrence.

Authors who have generalised on this part of the skull have hinted that ethnological differences occur. Martin (1928) says that the negro has the largest inferior orbital fissure, while in the Japanese it is mainly narrow and looks downwards. Wood Jones (1930) lists the spheno-maxillary fissure among the morphological features that should be taken into account when examining a skull for "racial" distinction. Others stress the large size of the fissure in the Australian aborigine. These statements seem to rest upon simple visual observations on small numbers of skulls. It is felt that more reliable conclusions might emerge from statistical analysis of measurements made upon a larger number of skulls.

One hundred Australian aboriginal skulls, mostly of South Australian origin, ten European, three Chinese, two Japanese, and four African skulls were examined. To avoid unnecessary complication only male skulls were selected. It is unfortunate that more non-aboriginal skulls were not available for comparison.

The Australian Aboriginal Skull (fig. 15)

The postorbital wall is formed mainly by the zygomatic bone anteriorly and the greater wing of the sphenoid posteriorly. The frontal and the maxilla may play a part in the wall on the extreme superior and inferior borders respectively. There is a certain amount of individual variation in the size and shape of these bones and when the zygomatic and the sphenoid meet the frontal at a more inferior level than usual the frontal forms part of the postorbital wall. Similarly, the maxilla may have a process that runs up the anterior border of the inferior orbital fissure, so becoming one of the bones of the postorbital wall.

The suture lines show only small individual variations. The borders of the inferior orbital fissure are formed by the sphenoid, zygomatic and the maxilla, except in 28%, where a spheno-maxillary junction excludes the zygomatic bone.

The inferior orbital fissure at first glance appears to have no particular shape, but on closer analysis three main types can be distinguished, as noted by Wood Jones (1930). The first is the "narrow" type, the second is the "wide" type, and the third is the "wide at the anterior end" type (fig. 15).

In the hundred skulls examined, type three represented 48%, while types one and two represented 24% and 28% respectively. With each of these three main types there may be two additional variations. The sphenoid may be close to the maxilla or it may be some distance laterally. Using these

two variations, six subtypes can be formed. The type with the sphenoid close to the maxilla and with a narrow inferior orbital fissure has the most complete postorbital wall, while the type with a wide fissure and well separated sphenoid has the most deficient postorbital wall.

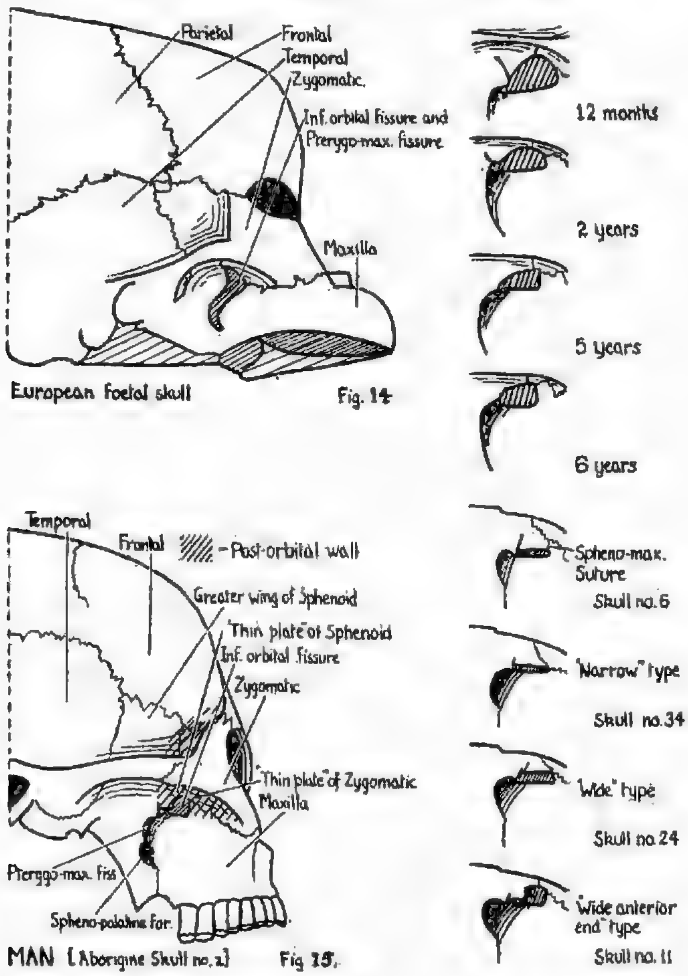

Fig. 14 - 15

The pterygo-maxillary fissure is a part of the general spheno-maxillary system. It continues the posterior end of the inferior orbital fissure, and for completeness must be considered also. For each skull a record was kept of the depth (either deep or shallow) and of the width (wide or narrow). There seemed to be no size relationship between the two fissures. In many cases a wide pterygo-maxillary fissure was associated with a narrow inferior orbital fissure. The infra-temporal surface of the sphenoid plays a part in the lateral projection of the area of the inferior orbital fissure. Although that surface does not alter the actual size of the fissure it may, as a spine, crest or thick bulge, hide the posterior end of the inferior orbital fissure from the lateral view to a varying degree.

The greater wing of the sphenoid, as it forms the superior border of the inferior orbital fissure, may be divided into two parts. The posterior part is thick in the region of the infra-temporal crest and the pre-pterygoid spine, but the anterior part is a thin plate. This thin plate is in contact with

a thin plate-like extension from the zygomatic (fig. 15, skull No. 2). Most variations in the inferior orbital fissure occur where these thin plates meet.

The size of the anterior end of the inferior orbital fissure depends upon the degree of development of these plates, and on the distance the sphenoid is lateral from the maxilla.

Reference to the foetal skull is instructive (fig. 14). The fissure is wide and runs downwards into the pterygo-palatine fossa, connecting this fossa with the orbit. In the 12-month-old skull (fig. 14), the inferior orbital fissure is still wide but the pterygo-maxillary fissure has become narrower. In the 2, 5, and 6-year-old skulls (fig. 14), the thicker part of the sphenoid has grown down in the region of the infra-temporal crest, but the thin plates of the sphenoid and zygomatic are undeveloped, leaving the fissure still widely open in front. It is easy to see that, from this generalised stage, the inferior orbital fissure could either remain wide or narrow to a slit according to the amount of subsequent expansion of the two thin plates. In the foetus the horizontal projection of the area of the fissure is large and the sphenoid is well lateral to the maxilla. The area may remain large in the adult skull or it may be decreased either by enlargement of the maxillary sinus or by medialwards expansion of the sphenoid.

Three aboriginal skulls have been chosen which show the three most common variations in this region.

Skull No. 24 (fig. 15) shows the usual formation of bones in the postorbital wall, with zygomatic anteriorly, greater wing of the sphenoid posteriorly and the frontal superiorly.

The bones forming the boundary of the inferior orbital fissure are of the common pattern. The greater wing of the sphenoid forms the posterior border, the zygomatic, maxilla and palatine forming the anterior, inferior and posterior borders respectively.

In this case the inferior orbital fissure is exceptionally wide and can be classified as the "wide" type. The pterygo-maxillary fissure is also wide.

In skull No. 6 (fig. 15), the boundaries of the inferior orbital fissure show some variation. The posterior, superior, and inferior borders of the fissure are formed by the palatine, the greater wing of the sphenoid and the maxilla respectively. The maxilla has sent a process in a postero-superior direction to meet the sphenoid and exclude the zygomatic from the fissure. This small maxillary tongue thus forms part of the postobital wall. The inferior orbital fissure is small and well covered by the pre-pterygoid spine of the sphenoid, and is typical of the "thin" type. The pterygo-maxillary fissure is narrow and the pterygo-palatine fossa small.

Skull No. 11 (fig. 15) shows the "wide at the anterior end" type. The two thin plates of the sphenoid and the zygomatic are not so well developed and have left a large opening in the anterior end of the fissure.

The following measurements were made on the right side of all the skulls employed for this investigation. No female skulls were measured but the female skulls examined were similar to the male. In two skulls of 11 and 12-year-old aborigines, the normal adult form was present. Evidently the final pattern is attained relatively early and this would account for absence of obvious sexual distinction (see Abbie, 1947).

1. The length of the fissure.—i.e., from the palatine to the most anterior point of the fissure.
2. The maximum width.—This was found in most cases to be at the anterior end, but in a few in the middle or the posterior end.

3. Width at the anterior end.—This was in most cases the same as the maximum width.
4. Width at the pterygo-palatine end.—This was variable, in some cases the end was large and rounded, in others just a narrow slit.
5. Distance of the sphenoid from the maxilla.—This figure was arrived at by averaging the horizontal widths at the anterior end, the middle and the posterior end. The mean of these figures gave a basis for comparison between different skulls.
6. Area from lateral side.—This is the horizontal projection of the area of the fissure.
7. Area from the base of the skull.—This is the vertical projection of the area of the fissure.

The measurements were recorded in Tables I, II and III (Appendix 1). All figures were examined for their degree of variability. Those obtained at the 5% level are as follows (all measurements in mm.).

1.	Length of fissure - - - -	between	35.3	and	24.6
2.	Maximum width - - - -	„	7.9	and	2.1
3.	Width at anterior end - - -	„	8.3	and	1.5
4.	Width at pterygo-palatine end -	„	4.9	and	1.5
5.	Distance sphenoid from maxilla -	„	4.1	and	0.9
6.	Area from lateral side - - -	„	92.5	and	0
7.	Area from base - - - -	„	118.6	and	13.3

Take 1 as an example. There is a difference of range of 10.7 mm. This is 38% of the mean length of the fissure (30 mm.). The other figures show an even greater percentage variation. In the face of such variation it is impossible to give any definite size or shape for the inferior orbital fissure in the South Australian skull (Appendix 2).

Similar tests were applied to the European, Chinese and African skulls. Once again, no standard pattern could be found. Thus, so far as this comparative material goes, there appear to be no standard shapes or sizes of the inferior orbital fissure in different peoples. With this variation, it would seem unlikely that there is any ethnological significance in the size and shape of the fissure. This conclusion is confirmed by statistical analysis of the measurements taken (Appendix).

Combining the aboriginal skulls and the European in the "t" test for these figures, no significance was found in any of them at the 5% level (Appendix). This shows that, as far as these observations go, there is no significant difference between the South Australian aboriginal and European inferior orbital fissures. This is contrary to what might be gathered from inspection alone. Similar "t" tests were carried out between the Aboriginal and the Chinese and African skulls, and once again no significant difference was found.

ACKNOWLEDGMENTS

I am indebted to Professor A. A. Abbie for suggesting this subject for investigation and for advice and assistance throughout. I am also indebted to the Director of the South Australian Museum, who allowed me to use material in the Museum collection.

RECAPITULATION

1. Separation of the orbit from the temporal fossa has been followed from fishes up to man.

2. The postorbital wall, which effects this separation, is formed mainly by flange-like extensions from the surrounding bones—frontal, sphenoid and zygomatic. The maxilla is sometimes involved. Communication with the temporal and infratemporal regions is gradually reduced to a spheno-maxillary fissure which becomes partially differentiated into a pterygo-maxillary fissure and an inferior orbital fissure.
3. The first stage of this process in primates is seen in the lemur. It reaches an extreme, reducing the inferior orbital fissure in particular to a narrow slit, in the Cercopithecidae and in the orang and gorilla. The condition is less extreme, and the fissures are generally wider, in the gibbon and chimpanzee and in man. A limited phylogenetic survey indicates that the final form of the inferior orbital fissure is determined largely by the development of thin, plate-like extensions from the sphenoid and zygomatic. The final form is, apparently, attained relatively early in development.
4. In man the inferior orbital fissure shows a wide range of variation in size and shape. Statistical comparison of the Australian aborigine with a limited number of skulls of different origin disclosed no signicant ethnological distinction.

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APPENDIX 1

TABLE I — ABORIGINAL SKULLS

	1	2	3	4	5	6	7
No. of skull	Length of fissure	Maximum breadth	Width at anterior end	Width of Pterygo-palatine fossa end	Distance sphenoid is lateral from maxilla	Area from lateral side	Area from base
1	33	5	5	1	4	42	50
2	31	6	6	3	3	29	62
3	28	5	4	5	4	15.5	89
4	29	4	4	3.5	3	24	69
5	30	6	6	2	2.5	36.5	71
6	31	3	3	1.5	1.5	4	51
7	32	4	4	4	3	21	86
8	30	5	3.5	5	3	36	96
9	30	6	6	3.5	2.5	26	63
10	30	7	7	4	4	47	89
11	30	8	8	2	2	35	71
12	27	4	4	2	1.5	27	34
13	34	6	2	2	2.5	54	86
14	30	7	7	4	2	108	72
15	25	7	7	2	3	46	70
16	28	5	5	2	3	21	63
17	28	5	5	3	2	19	61
18	29	7	7	1	1.5	30	53
19	28	2.5	2.5	2	1	10	30
20	25	5	5	2	4	10	43
21	37	7	7	4	4	53	92
22	26	2	1	2	1	11	7
23	30	3	3	2	1.5	22	30
24	33	6	6	2	2.5	58	68
25	31	5	5	5	3.5	21	85
26	28	5	5	4	2.5	34	57
27	31	4	4	3	3	21	51
28	22	4	4	2	2	15	34
29	31	5	5	3	3	25	76
30	31	7	7	2	2.5	47	59
31	28	6	6	3	3	40	99
32	34	5	5	4	2.5	20	82
33	33	6	5	2	2.5	50	87
34	33	3	3	3	2	2	47
35	28	7	7	2	2	52	57
36	27	7	7	2	3	36	62
37	27	3	1	3	1.5	2	31
38	34	4	4	4	3	15	87
39	32	5	5	4	3	13	52
40	33	5	5	3	3	21	64
41	23	4	4	4	2.5	10	39
42	32	7	2	4	3	49	86

TABLE 2

ABORIGINAL SKULLS (continued)

	1	2	3	4	5	6	7
No. of skull	Length of fissure	Maximum breadth	Width at anterior end	Width of Pterygo-palatine fossa end	Distance sphenoid is lateral from maxilla	Area from lateral side	Area from base
43	30	5	5	2	2	44	76
44	34	7	7	2	3	101	45
45	32	5	5	3	2.5	39	87
46	30	3	2	3	2	4	25
47	31	5	5	3	2	58	74
48	32	5.5	5.5	4	2.5	52	87
49	25	9.5	9.5	4	3	33	57
50	30	5	5	5	3	54	81
51	30	4	4	2	1.5	23	42
52	30	7	7	3	2	47	63
53	29	3	2	3	2	7	58
54	33	4.5	4.5	3	2.5	58	88
55	26	1	4	4	2	0	56
56	34	11	11	5	6	215	203
57	28	4	4	3	2	11	63
58	35	6	6	3	2.5	85	95
59	32	5	5	3	2.5	53	90
60	34	4	4	3	2.5	67	71
61	25	2	2	1	1	8	27
62	32	6	6	4	3	61	77
63	32	4	4	4	2.5	37	80
64	30	2	2	2	2	15	42
65	28	4	4	4	2	6	49
66	30	4	4	3	2.5	10	65
67	25	3	3	3	2	6	55
68	35	6	6	3	2.5	44	68
69	28	4	4	3	2	45	49
70	25	6	6	5	2	43	77
71	35	8	8	3	2.5	71	77
72	30	5	5	3	2	47	59
73	29	4	4	3	2.5	61	53
74	30	4	4	4	2.5	41	63
75	31	7	7	3	2	76	61
76	29	3	3	3	2	20	50
77	30	4	4	3	2.5	29	70
78	29	5	5	3	2	38	53
79	28	5	5	4	3	34	64
80	32	7	7	3	3	75	90
81	29	4	4	4	2.5	20	86
82	31	2	2	1.5	1.5	0	35
83	29	4	2	4	2	18	51
84	30	6	6	4	3	53	89

TABLE 3

ABORIGINAL SKULLS (continued)

	1	2	3	4	5	6	7
No. of skull	Length of fissure	Maximum breadth	Width at anterior end	Width of Pterygo-palatine fossa end	Distance sphenoid is lateral from maxilla	Area from lateral side	Area from base
85	31	5	6	6	3.5	36	103
86	30	4	4	4	2.5	8	70
87	27	5	5	4	3	50	82
88	31	6	6	4	3	47	83
89	32	3	3	3	2	29	47
90	32	5	5	3	2	38	52
91	32	6	6	4	3	62	102
92	29	6	6	4	2.5	48	74
93	27	6	6	5	3	54	123
94	29	4	3.5	4	3	7	80
95	25	4	4	3	2.5	4	55
96	30	6	6	4	2.5	62	87
97	32	4	4	4	2	38	68
98	30	5	5	3	2.5	29	85
99	31	7	7	4	3.5	79	116
100	31	4	4	2	1.5	19	50
EUROPEAN SKULLS							
1	28	4	4	3	2.5	35	62
2	28	6	6	5	2	39	75
3	28	3	3	3	2	9	37
4	29	5	5	4	2	40	65
5	32	3	3	3	2.5	30	91
6	25	5	5	3	2	21	32
7	27	4	4	3	2.5	17	61
8	27	7	7	3	2	34	43
9	27	4	3	4	2	9	50
10	31	5	5	3	2.5	31	59
AFRICAN SKULLS							
1	30	7	7	4	2.5	65	64
2	27	8	8	4	3	64	97
3	27	8	8	4	2.5	67	82
4	29	3	3	2	2	34	51
CHINESE SKULLS							
1	32	4	2	4	2	20	74
2	30	5	5	2	1.5	42	34
3	30	3	3	2	1.5	10	39
JAPANESE SKULLS							
1	28	2	1	2	1.5	3	37
2	32	7	7	4	3	30	87

APPENDIX 2

LENGTH OF FISSURE

Aboriginal.

$Sx_1^2 = 90558$

$Sx_1 = 2997$

$\bar{x}_1 = 29{\cdot}97$

$\sigma_1^2 = 90558 - 89820$

$= \underline{738}$

$\dfrac{(29{\cdot}97 - \alpha)100}{\sqrt{738}} = \pm t{\cdot}05$ with 99 d.f.

$= \pm 1{\cdot}98$

$29{\cdot}97 - \alpha = \pm 5{\cdot}36$

$\therefore \alpha$ between $35{\cdot}3$ & $24{\cdot}6$

European.

$Sx_2^2 = 7990$

$Sx_2 = 282$

$\bar{x}_2 = 28{\cdot}2$

$\sigma_2^2 = 7990 - 7950$

$= \underline{40}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \dfrac{\sigma_1^2}{100} + \dfrac{\sigma_2^2}{10}$

$= 7{\cdot}38 + 4 = 11{\cdot}38 = (3{\cdot}37)^2$

$t = \dfrac{1{\cdot}8}{3{\cdot}37} = \underline{{\cdot}53}$ at 110 d.f.

not significant ($P \doteq {\cdot}6$)

MAXIMUM WIDTH

Aboriginal.

$Sx_1^2 = 2776$

$Sx_1 = 504{\cdot}5$

$\bar{x}_1 = 5{\cdot}0$

$\sigma_1^2 = 2776 - 2545$

$= \underline{221}$

$\dfrac{(5{\cdot}0 - \alpha)100}{221} = \pm t{\cdot}05$ with 99 d.f.

$= 1{\cdot}98$

$5{\cdot}0 - \alpha = \pm 2{\cdot}9$

$\therefore \alpha$ between $7{\cdot}9$ & $2{\cdot}1$

European.

$Sx_2^2 = 226$

$Sx_2 = 46$

$\bar{x}_2 = 4{\cdot}6$

$\sigma_2^2 = 226 - 211{\cdot}6$

$= \underline{14{\cdot}4}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \dfrac{\sigma_1^2}{100} + \dfrac{\sigma_2^2}{10}$

$= 2{\cdot}21 + 1{\cdot}44 = 3{\cdot}65 = (1{\cdot}91)^2$

$t = \dfrac{{\cdot}4}{1{\cdot}91} = \underline{{\cdot}209}$ at 110 d.f.

not significant ($P \doteq {\cdot}83$)

WIDTH AT ANTERIOR END

Aboriginal.

$Sx_1^2 = 2640{\cdot}5$

$Sx_1 = 484{\cdot}6$

$\bar{x}_1 = 4{\cdot}9$

$\sigma_1^2 = 2640{\cdot}5 - 2342$

$= \underline{298{\cdot}5}$

$\dfrac{(4{\cdot}9 - \alpha)100}{298{\cdot}5} = \pm t{\cdot}05$ with 99 d.f.

$= \pm 1{\cdot}98$

$(4{\cdot}9 - \alpha) = \pm 3{\cdot}42$

$\therefore \alpha$ between $8{\cdot}3$ & $1{\cdot}5$

European.

$Sx_2^2 = 219$

$Sx_2 = 45$

$\bar{x}_2 = 4{\cdot}5$

$\sigma_2^2 = 219 - 202{\cdot}5$

$= \underline{16{\cdot}5}$

Combined

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \dfrac{\sigma_1^2}{100} + \dfrac{\sigma_2^2}{10} = 2{\cdot}99 - 1{\cdot}65$

$= 4{\cdot}64 = (2{\cdot}154)^2$

$t = \dfrac{{\cdot}4}{2{\cdot}154} = \underline{{\cdot}1857}$ at 110 d.f.

not significant ($P \doteq {\cdot}85$)

WIDTH AT PTERYGO-PALATINE FOSSA END

Aboriginal.

$Sx_1^2 = 1101$

$Sx_1 = 320{\cdot}5$

$\bar{x}_1 = 3{\cdot}2$

$\sigma_1^2 = 1101 - 1027$

$= \underline{74}$

$\dfrac{(3{\cdot}2 - \alpha)100}{74} = \pm 1{\cdot}98$

$3{\cdot}2 - \alpha = \pm 1{\cdot}7$

$\therefore \alpha$ between $4{\cdot}9$ & $1{\cdot}5$

European.

$Sx_2^2 = 120$

$Sx_2 = 34$

$\bar{x}_2 = 3{\cdot}4$

$\sigma_2^2 = 120 - 115{\cdot}6$

$= \underline{4{\cdot}4}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \dfrac{\sigma_1^2}{100} + \dfrac{\sigma_2^2}{10} = {\cdot}74 + {\cdot}44$

$= 1{\cdot}18 = (1{\cdot}086)^2$

$t = \dfrac{{\cdot}2}{1{\cdot}086} = \underline{{\cdot}1841}$ at 110 d.f.

not significant ($P \doteq {\cdot}85$)

DISTANCE SPHENOID IS LATERAL FROM MAXILLA.

Aboriginal.

$Sx_1^2 = 686\cdot75$

$Sx_1 = 284\cdot5$

$\bar{x}_1 = 2\cdot5$

$\sigma_1^2 = 686\cdot75 - 617\cdot7$

$= \underline{\underline{69\cdot1}}$

$\frac{(2\cdot5-\alpha)100}{69\cdot1} = \pm1\cdot98$

$2\cdot5-\alpha = \pm1\cdot64$

$\therefore \underline{\alpha \text{ between } 4\cdot1 \text{ \& } \cdot9}$

European.

$Sx_2^2 = 49$

$Sx_2 = 22$

$\bar{x}_2 = 2\cdot2$

$\sigma_2^2 = 49 - 48\cdot4$

$= \underline{\underline{\cdot6}}$

Combined

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10} = \cdot69 + \cdot06$

$= \cdot751 = (\cdot866)^2$

$t = \frac{\cdot3}{\cdot866} = \underline{\cdot347}$ at 110 d.f.

not significant ($P \doteqdot \cdot73$)

AREA FROM LATERAL SIDE

Aboriginal.

$Sx_1^2 = 217431\cdot5$

$Sx_1 = 3785$

$\bar{x}_1 = 37\cdot85$

$\sigma_1^2 = 217431 - 143300$

$= \underline{\underline{74131}}$

$\frac{(38\cdot39-\alpha)100}{74131} = \pm1\cdot95$

$38\cdot39 - \alpha = \pm54\cdot1$

$\therefore \underline{\alpha \text{ between } 92\cdot5 \text{ \& } 0}$.

European.

$Sx_2^2 = 8255$

$Sx_2 = 265$

$\bar{x}_2 = 26\cdot5$

$\sigma_2^2 = 8255 - 7021$

$= \underline{\underline{1234}}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_1) = 701\cdot3 + 123\cdot4$

$= 824\cdot7 = (28\cdot718)^2$

$t = \frac{11\cdot89}{28\cdot72} = \underline{\cdot414}$ at 110 d.f.

not significant ($P \doteqdot \cdot68$)

AREA FROM BASE

Aboriginal.

$Sx_1^2 = 522361$

$Sx_1 = 6699$

$\bar{x}_1 = 66\cdot99$

$\sigma_1^2 = 522361 - 448700$

$= \underline{\underline{73461}}$

$\frac{(66\cdot99-\alpha)100}{73461} = \pm1\cdot98$

$66\cdot99 - \alpha = 53\cdot67$

$\therefore \underline{\alpha \text{ between } 118\cdot6 \text{ \& } 13\cdot3}$

European.

$Sx_2^2 = 35919$

$Sx_2 = 575$

$\bar{x}_2 = 57\cdot5$

$\sigma_2^2 = 35919 - 33070$

$= \underline{\underline{2849}}$

Combined.

$\sigma(\bar{x}_1 - \bar{x}_2)^2 = 734\cdot61 + 284\cdot9 = 1019\cdot5 = (31\cdot93)^2$

$t = \frac{9\cdot49}{31\cdot93} = \underline{0\cdot297}$ at 110 d.f.

not significant ($P \doteqdot \cdot77$)

THE ADELAIDE SYSTEM AS DEVELOPED IN THE RIVERTON-CLARE REGION, NORTHERN MOUNT LOFTY RANGES, SOUTH AUSTRALIA

BY ALLAN F. WILSON

Summary

A reconnaissance geological survey of the Riverton-Clare region has revealed a thick and extensive development of a remarkably complete sequence of the lower formations of the Adelaide System (Late Proterozoic). A feature is the thick ilmenitic sandstone lithologically identical with the basal grits of Howchin's type area in the Torrens Gorge, and at Aldgate, and also with Mawson's "Basal Quartzite" of the Flinders Ranges. This sandstone, however, does not pass down into an unconformity with the Older Pre-Cambrian, but fairly gradually gives away to at least 8,000 feet of alternating shales, sandstones, and occasional calcareous rocks. These were not bottomed, and thus represent the oldest sediments of the Adelaide System of this area.

THE ADELAIDE SYSTEM AS DEVELOPED IN THE RIVERTON-CLARE REGION, NORTHERN MOUNT LOFTY RANGES, SOUTH AUSTRALIA

By Allan F. Wilson*

[Read 8 November 1951]

1. SUMMARY

A reconnaissance geological survey of the Riverton-Clare region has revealed a thick and extensive development of a remarkably complete sequence of the lower formations of the Adelaide System (Late Proterozoic). A feature is the thick ilmenitic sandstone lithologically identical with the basal grits of Howchin's type area in the Torrens Gorge, and at Aldgate, and also with Mawson's "Basal Quartzite" of the Flinders Ranges. This sandstone, however, does not pass down into an unconformity with the Older Pre-Cambrian, but fairly gradually gives way to at least 8,000 feet of alternating shales, sandstones, and occasional calcareous rocks. These were not bottomed and thus represent the oldest sediments of the Adelaide System of this area.

Dolomites of the Torrens Gorge are represented by upwards of 1,100 feet of mainly cream dolomites. Those arenites, which are taken as comparable with the Stonyfell (Thick) Quartzite near Adelaide, are at least of double its thickness. There are over 4,000 feet of dolomitic shales and interbedded dense blue-grey dolomites reminiscent of the Beaumont Dolomites, and a "Sturtian" tillite of meagre proportions. The total thickness of the Torrensian (Lower Adelaide) Series is about 30,000 feet, which is considerably more than thrice the thickness in the type area. This estimate, however, could be somewhat reduced should more detailed mapping reveal repetition due to faulting.

During middle Palaeozoic times the geosynclinal pile was thrown into a series of meridionally trending folds of considerable magnitude, but there is virtually no metamorphism and igneous rocks are absent in the area under discussion.

In general, compressional forces appear to have come from the east. In part of the area, however, there is a major drag on the meridionally trending structure. This indicates that in the western part of the area there has been a major movement "south and down" relative to a "north and up" movement on the east. Study of consequences of such relative movement satisfactorily explains the peculiar variations in trends of fold axes shown by subsidiary folds near the nose of the major drag.

Only two major faults were recognised; these, the Alma and the Gilbert Range faults, are more or less meridional and have allowed renewed movement during the late Tertiary.

Mineralization is so meagre that various building stones appear to comprise the main direct interest for the economic geologist.

2. INTRODUCTION AND PREVIOUS INVESTIGATIONS

It was originally proposed to carry out a detailed study of the western section of the Mount Lofty Ranges with a view to studying facies changes from Howchin's type locality for the (late Proterozoic) Adelaide System some 70 miles to the south. However, the author's departure from South Australia in 1949 has necessitated publication of this unfinished work in its present form.

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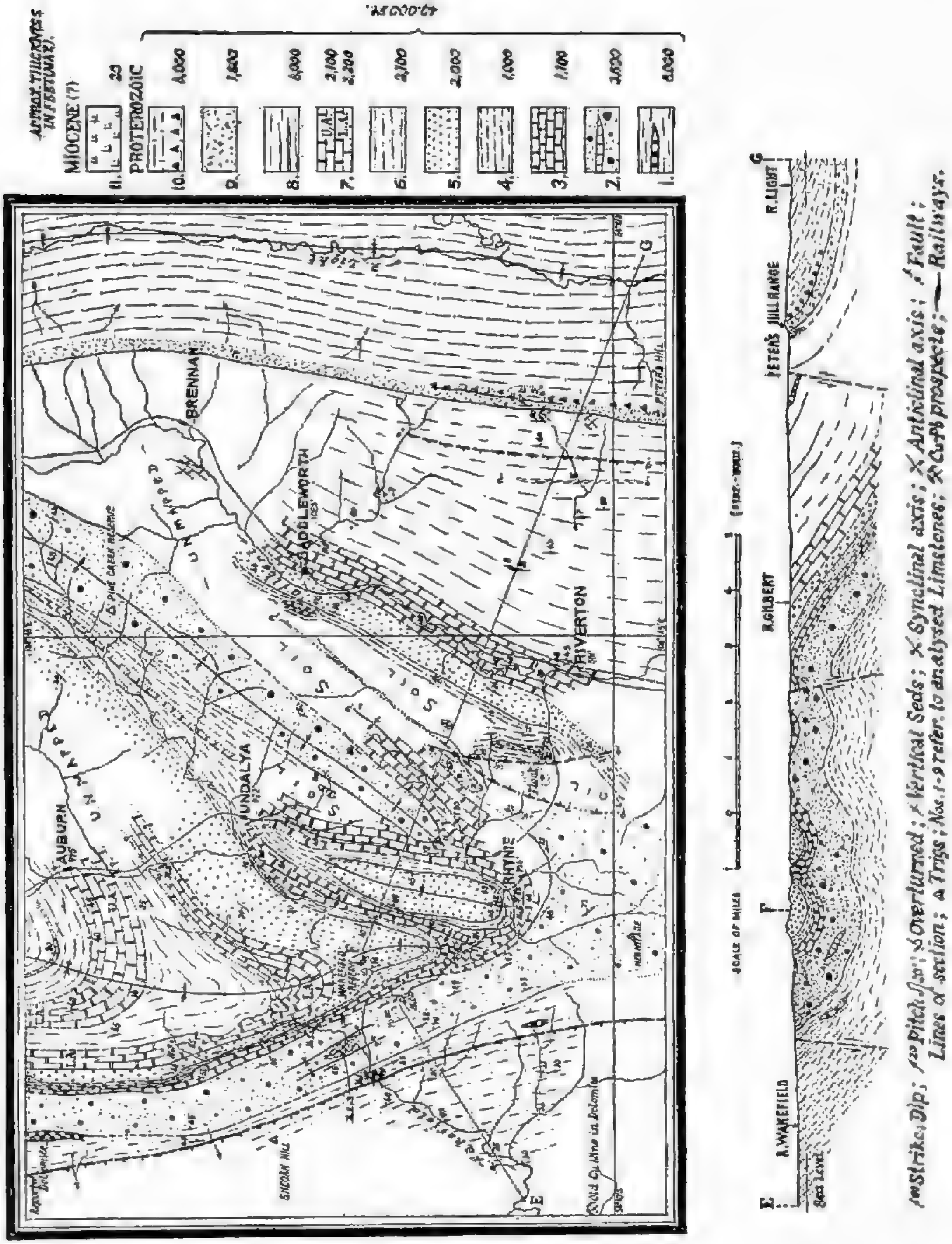
MIOCENE (?)
PROTEROZOIC
AUBURN
UNDALYA
SADDLEWORTH
RIVERTON
RHYNIE
BRENNAN
UNMAPPED
SOILS
PETER'S HILL RANGE
R. GILBERT
R. LIGHT
R. WAKEFIELD
SCALE OF MILES
Sea Level

Fig. 1

Land Survey plans (2 inches = 1 mile) were used as base maps in the first instance, but the map for publication has been drawn on a scale of 1 inch = 1 mile. Chain, compass and abney-level, or pacing compass and aneroid methods were used. Unfortunately, aerial photographs were not available till almost at the end of this work. As much of the land is cultivated, many photographs only serve to aid location of one's position which is not difficult to fix by normal methods. The structure south of Auburn, however, could be verified by their use and considerable help obtained in tracing the arenaceous formations further north to link with the reconnaissance work done near Clare. Little structure could be seen from photographs taken N.E. of Auburn.

The area surveyed is bounded roughly by the Gilbert Range on the east, the Clare-Farrell Flat line in the north, the Alma Fault Scarp in the west, and the Riverton-Rhynie line in the south (i.e., 25 miles N.-S. x 18 miles E.W. is the maximum area studied). (See fig. 2.)

No previous attempt has been made at geological mapping, indeed only scanty references to this area can be found in the literature. Howchin (1927) observed "Sturtian" tillite in the Gilbert Range between Tarlee and Kapunda. Hossfeld (1934) named the formation beneath the tillite the Gilbert Range Subglacial Quartzite, thus recognising the extension of this valuable marker bed into the area now under discussion. Both Howchin (1929, p.30) and Jack (1923, p. 28) suggest that the famous Mintaro Slates are possibly of fluvio-glacial origin, or are associated at least in some way with the tillite which Jack casually mentions as occurring a few miles west of Mintaro. Jack (1923) notes the use of slate for building stone near Auburn (p. 35) and Clare (p. 27), and of freestones near Clare (p. 65). In various South Australian Mining Reviews occasional mention is made of small alluvial gold or copper deposits.

3. PHYSIOGRAPHY

The Riverton-Clare region is part of the Northern Mount Lofty Ranges which have been limited to those highlands between the latitude of Gawler in the south, and Crystal Brook-Jamestown line in the north. Fenner (1931, p. 317) in his general description of the area states that "the mountains to the north and south of this region (Flinders and Mount Lofty Ranges, respectively) are of much higher relief and lower economic value that the meridional ranges and ridges of the Northern Mount Lofty Ranges with their wide alluvial-filled valleys. Over the greater part of this region the soils are excellent; cultivation extends alike over the hills and the valleys, so gentle is the relief; but there are also some steep and stony hills of pastoral value only." The climate is typically Mediterranean with a reliable winter-maximum rainfall of between 18 and 30 inches.

KEY TO FIGURES 1 and 2

(1) River Wakefield Group of alternating sandy shales
(2) Rhynie Sandstone, ilmenitic arkosic sandstone with interbedded Dolomites
(3) Skillogalee Dolomites
(4) Woolshed Flat Shales
(5) Undalya Quartzite
(6) Watervale Sandstone, argillaceous, and lensing out E.
(7) Auburn Dolomites and interbedded dolomitic shales, divided by six into upper (U.A.) and lower (L.A.) members
(8) Mintaro Shales, with Leasingham quartzite member
(9) Gilbert Range Quartzites and interbedded Fluvio-glacial Sediments
(10) Glacial and Fluvioglacial Sediments and Shales
(11) Laterite

In the area under discussion both the gentle relief and best soils are confined to those areas underlain by argillaceous, tillitic and dolomitic rocks. The arenaceous rocks form resistant ridges, and invariably give rise to poor sandy soils. The general relief falls off to the south from an average elevation in the Clare-Farrell Flat region of about 1,300 feet to about 800 feet in the neighbourhood of Riverton. No detailed topographic survey has yet been undertaken in this region.

The water courses throughout the area are mostly mature-subsequent. Elsewhere in the Mount Lofty and Flinders Ranges the drainage is mature-subsequent in the upper courses but is juvenile-consequent along the margins following earth movements in late Tertiary and Recent times. Study of the maps will reveal that not only do streams run parallel to the major formations but the unusual deflections in the Wakefield and Woolshed Flat Creek appear to be controlled in the main by the east-west cross-fold anticlinal axis and thickening of the arenites on the noses of the major pitching folds.

The lack of obvious superimposed streams and consequent streams (excepting those along the Alma Fault Scarp) presents an interesting problem. The lack of superimposed streams suggests that no significant superficial deposits have been laid down in this area on the poorly peneplaned surface. In this connection it is interesting to observe that the only residual laterite surface discovered had an appreciable dip of up to 5° eastward into the old valley of the Light. The Light, and probably most of the other major streams, were flowing through mature river valleys in pre-laterite times. The area was insufficiently peneplaned for the laterite deposits to have any appreciable effect on the drainage systems.

4. GEOLOGY

The area under discussion was part of the great Adelaide Geosyncline of late Proterozoic-early Palaeozoic age. Its position is an interesting one in that it is in the Northern Mount Lofty Ranges and between 60 and 90 miles north of Howchin's type area for the Adelaide System near Adelaide, and about half-way between the type area and the Peterborough region which has been thought to have been a very deep part of the geosyncline.

The area is almost entirely made up of a varied suite of sediments (sandstones, shales, greywackes, dolomites, and tillites) of upper Proterozoic age. Though considerably folded and less conspicuously faulted the sediments are virtually unmetamorphosed. For descriptive purposes the various units of the Adelaide System are described in ascending stratigraphic order.

A. STRATIGRAPHY

I. PROTEROZOIC

(1) Adelaide System

(a) River Wakefield Group

An extensive group of alternating sandy phyllites, quartzites and occasional lenticular bodies of dolomite and limestone comprise the oldest rocks outcropping in this area. The group makes good outcrops in most of the consequent water courses dissecting the Alma Fault Scarp, but it is particularly well developed in those which join the River Wakefield within 3 or 4 miles west of the Scarp.

The sediments are all fine to medium grained, with graded bedding well shown in certain horizons. No coarse grits or conglomerate lenses were found and many are typical greywackes. Slump structures and occasional minor cross-bedding all indicate the west-north-west as the source of detrital

material. Heavy mineral concentration is uncommon. Ilmenite-rich zones, however, have been noted several hundred stratigraphic feet below the great ilmenitic formation, the Rhynie Sandstone, into which the River Wakefield Group appears to pass without unconformity (e.g., 2 miles E. of Hoyleton, on the road to Leasingham). The colour of the sediment is usually a pale dove-grey. No red beds are noted.

Interbedded usually with the argillaceous sections of the group are occasional *carbonate rocks* of various types. Immediately beneath the bridge on the Wakefield 5 miles north-west of Rhynie is a calcareous zone in sandy phyllites and sandstones. On analysis a sample (Table I, No. 1, and No. 1 of map) from a 6 feet thick calcareous bed revealed a high ratio of $CaCO_3$ to $MgCO_3$ (viz., 8·2 : 1). This is far greater than that of any other of nine calcareous rocks analysed from the area. In handspecimen the rock is best described as a white arenaceous oolitic limestone.

More commonly the calcareous members are pale cream-coloured massive very finely-grained dolomites, similar in appearance to those of the stratigraphically higher Skillogalee Dolomites. Examples are reported to occur 2½ miles east of Hoyleton on the Leasingham road, and near the road 3 miles due west of Rhynie. Unfortunately, no analyses of dolomites of this type were made.

Another calcareous rock was noted less than ¼ mile upstream from the bridge over the Wakefield, five miles N.W. of Rhynie. It is a 2-3 foot lens of thin-bedded dense blue-grey dolomite. The rock is intercalated in light-grey sandy phyllites.

Throughout the area the River Wakefield Group has been thrown into a series of minor folds. In addition these beds show considerable crushing and shattering near the large Palaeozoic fault zone (rejuvenated in the late Tertiary to form the Alma Fault Scarp). Most Palaeozoic faults in the Mount Lofty Ranges betray their presence by large displays of a cellular "fibrous" quartz which appears *in situ* in places, but is more commonly seen as abundant floaters in the fields.

Notwithstanding the folding and faulting it seems that about 8,000 feet of sediments of this group are exposed within the type area.

(b) Rhynie Sandstone

This formation comprises the backbone of a ridge extending from near Rhynie to beyond Clare. The formation is essentially an ilmenite-rich feldspathic sandstone. There are plentiful but thin intercalated sandy shales and shaly sandstones. In places (e.g., just upstream from the junction of Woolshed Flat Creek and the Wakefield) a bed of some 20 feet of coarse conglomerate may be seen, which may be traced along the strike for a furlong before it lenses out. On account of this feature, viz., the limited linear outcrop of any particular horizon, the assemblage of ilmenitic sandstones is best considered as one formation.

One of the most characteristic features of this formation is the striking development of coarse crossbedding which is clearly outlined by abundant detrital ilmenite and haematite. In none of the several other arenaceous formations in the area is the crossbedding thus delineated. Ilmenite has been noted in the River Wakefield Group (q.v.) and indicates a transition between that group and the Rhynie Sandstone. In one area (1½ miles east of Wakefield Reserve) the Undalya quartzite was found with considerable ilmenite crossbedding. These exceptions need not nullify a useful field criterion.

Slump structures are present but much rarer than in the slower-forming sediments of the River Wakefield Group. Graded bedding and impressions

made by dropped pebbles in bands of heavy minerals are well shown in parts. Ripple marks were not noticed. This wealth of primary features greatly facilitates the determination of sequence. The crossbedding indicates that the source of detrital material was west-north-west, a fact borne out by the close resemblance of certain of the Northern Yorke Peninsula granites and the fragments of pink granite in the conglomerates.

An interesting feature is the lack of a coarse facies (conglomerate or grit) at the base of this formation. Rather it is found that the River Wakefield Group contains in places ilmenite-bearing arenites and indicates a fairly gradual shallowing of the sedimentary basin. The conglomerate occurs as isolated lenses throughout the formation but particularly about two-thirds of the stratigraphic distance up from the "base."

Careful study of primary structural features (crossbedding, supplemented by graded bedding) has shown that this massive arenaceous formation has suffered considerable folding, thus rendering difficult an estimation of true thickness. An instructive section is that afforded by a 1½ miles walk upstream along the Wakefield from its confluence with the Woolshed Flat Creek. Though all the beds dip steeply eastward there are at least four changes in sequence direction. In this particular section the steeper set of beds (i.e., 80°-90° E.) usually "young west," whereas the more shallowly dipping set (i.e., 65°-70° E.) "young east." This complex structure was not expected in such a massive formation but some of the folds can be seen from the top of the south bank of the Wakefield when one looks north from a point ¼ mile due north of Mr. Bowden's homestead which is $^1/_3$ mile up the Woolshed Flat Creek above its confluence with the Wakefield. These structures are large tectonic drags on the west limb of a major north-pitching syncline.

Interbedded Dolomites

A surprising feature of this formation is the presence of a number of dolomitic members. These are well exposed in the bed of the Wakefield about one mile upstream from its confluence with the Woolshed Flat Creek. In a band 150-200 feet thick the typical rock is a cream-colored dense fine-grained calcareous magnesite. On analysis (see Table I, No. 3 and No. 3 of map) a $CaCO_3$: $MgCO_3$ ration of 0·21 was found. The rock is homogeneous and perfectly fresh. There are no magnesite mud-curls or "Mawsonella" inclusions as in some dolomites of the Upper Torrens Group. The magnesite, though similar in appearance, differs chemically from normal Skillogalee dolomites.

A very pale dull-blue fine-grained dense dolomite occurs as a narrow bed some five feet thick toward the base of the major band of cream-coloured magnesite. On analysis this rock proves to be a normal dolomite with $CaCO_3$: $MgCO_3$ ration of 1·24 (Table I, No. 2, and No. 2 of map). In this it is similar to the cream-coloured dolomite which outcrops on the road just west of Kemp's homestead 3½ miles N.W. of Rhynie. This appears to be interbedded in the same Rhynie Sandstone but is probably nearer its contact with the Skillogalee Dolomites than those described above (mapping was hurried and general in this area). It is a cream-coloured dense fine-grained dolomite which on analysis showed a $CaCO_3$: $MgCO_3$ ratio of 1·21 (Table I, No. 4 and No. 4 of map). Comparison with other analyses in Table I indicates the remarkable purity of this dolomite.

(e) Skillogalee Dolomites

The major dolomites of the area form a very important stratigraphic marker as they separate the two most important sandstones. They are cream-

TABLE I

Analyses of dolomites from Torrensian (Lower Adelaide) Series, as developed in the Riverton-Clare and in the Adelaide type area.

No.	Locality	Formation	Suggested Correlation	Description	Analyst	$CaCO_3$	$MgCO_3$	Insol., etc.	$Fe_2O_3 + Al_2O_3$	Total	Ratio $CaCO_3/MgO_3$
1*	River Wakefield; Bridge S.E. Sec. 75, Hd. Up. Wakefield (5 m. N.W. Rhynie)	R. Wakefield Group	—	Sandy oolitic white limestone	T.R.F.	46.72	5.70	46.98	0.60	100.00	8.20
2*	R. Wakefield; near Bowden's E. Sec. 68, Hd. Up. Wakefield (5 m. N.W. Rhynie)	Rhynie SS.	—	Pale blue dol. assoc. with 3	"	47.22	38.20	12.42	1.66	99.50	1.24
3*	Do.	Do.	—	Cream calc. magnesite bed assoc. with 2	"	14.66	71.54	11.58	1.92	99.70	0.21
4*	Near Kemp's, on road bet. Sec. 508, 506 Hd. Alma (3½ m. N.W. Rhynie)	Upper Rhynie SS. ?	—	Cream dol.	"	53.76	44.40	1.14	0.98	100.28	1.21
5*	R. Wakefield, Sec. 65, Hd. Up. Wakefield (5 m. N.W. Rhynie)	Skillogalee dols.	Castambul (L. Torrens) dol.	Cream dol.	"	50.86	41.46	6.20	1.22	99.74	1.23
6	Torrens Gorge	Castambul (U. Torrens) dol.	—	Light buff dol.	T.W.D.	49.2	42.5	7.8		99.5	1.16
7	Do.	Do.		Do.	"	50.9	44.1	4.7		99.7	1.16
8*	¾ m. N.W. Rhynie on road bet. Sec. 210 and 557 Hd. Alma	Upper Skillogalee dols.	Montacute (U. Torrens) dol.	Silic blue-grey dol.	T.R.F.	37.26	31.48	31.16	0.40	100.30	1.18
9	Torrens Gorge	Montacute (U. Torrens) dol. (Sprigg No. 3)	—	Light grey "Mawsonella" silic magnesite (assoc. with 10)	T.W.D.	6.5	72.0	21.6		100.1	0.09
10	Do.	Do. (No. 4)	—	Blue-grey dol.	"	44.5	36.7	17.0		98.2	1.21
11	Do.	Do. (No. 5)	—	Cherty blue-grey banded dol.	"	48.3	38.8	8.1		95.2	1.24

(T.R.F. = Thos. R. Frost; T. W. D. = T. W. Dalwood; * = new analyses.

TABLE II

Analyses of Dolomites from Torrensian (Lower Adelaide) Series

No.	Locality	Formation	Suggested Correlation	Description	Analyst	$CaCO_3$	$MgCO_3$	Insol., etc.	Fe_2O_3 + Al_2O_3	Total	Ratio $CaCO_3$/ MgO_3
12*	On road 3¾ m. W.S.W. Auburn, S.E. 547 Hd. Up. Wakefield	L. Auburn dols.	Beaumont dols.	Dense dark grey dol.	T.R.F.	37.42	27.48	30.12	4.64	99.66	1.36
13*	On road 1¾ m. S. Auburn, Sec. 275 Hd. Up. Wakefield	L. Auburn dols.	Do.	Lam. dense blue-grey dol.	,,	46.16	39.90	12.36	1.78	100.20	1.16
14*	Near Saddleworth, on road bet. Sec. 396 and 397, Hd. Saddleworth	Auburn dols.	Do.	Dense dark grey dol.	,,	37.46	29.74	29.90	2.40	99.50	1.26
15	Beaumont	Beaumont dols.	—	Dark grey dol.	T.A.B.	37.8	30.5	32.7		101.0	1.24
16	Mount Osmond turn-off	Do.	—	Dark grey dol.	,,	34.1	29.2	35.8		99.1	1.17
17	Beaumont	Do.	—	Dark grey dol.	,,	42.7	32.3	27.4		102.4	1.32
18	Mountain Hut	Do.	—	Dark grey dol.	A.W.K.	43.8	34.0	25.4		103.2	1.44

(T.R.F. = Thos. R. Frost; T.A.B. = T. A. Barnes; A.W.K. = A. W. Kleeman) * = new analyses.

coloured fine- to medium-grained dense dolomites with occasional interbedded dolomitic shales. Neither residual magnesite boulders nor "primary" magnesitic mud-curls were noted in the major development of the formation in the Skillogalee Creek and near Rhynie. However, in a road metal quarry half a mile west of Saddleworth a considerable quantity of high grade magnesite has been developed on the weathering of pale-blue dolomites which appear to belong to the same formation.

The formation has a variable thickness owing to its relative incompetency and position between two thick sandstone formations. The map shows moreover, that although the dolomites have "spread" themselves around the noses of the pitching folds near Rhynie, on the west limb of the major north-pitching syncline they are tightly squeezed and seem to disappear somewhere in the latitude of Watervale. Their disappearance is best explained as due to tectonic causes, for the Auburn Dolomites likewise disappear in the same relative position. Moreover the dolomites probably reappear in a milder tectonic setting further north in the Wirrabarra Forest region as Mawson's "Magnesite Series."

On analysis a typical specimen from this formation (Table 1, No. 5 and No. 5 of map) revealed a dolomite remarkably comparable with the light-buff Castambul (Lower Torrens) Dolomite[1] of Howchin's type area (see also Table I, No. 6 and 7). It has a $CaCO_3 : MgCO_3$ ratio of 1·23.

Near the bridge at Undalya the dolomites are tightly folded and recrystallized into light-buff and cream marble. About one mile downstream pale-blue dolomitic rocks are well developed. They occur intimately associated but stratigraphically above the light-buff and cream dolomites so typical of the Skillogalee formation. In one place (+) 95 feet of blue dolomite was found overlain by 560 feet of dark-grey sandy shale which in turn is overlain by the Undalya Quartzite. This blue dolomite may prove to be the equivalent of the Montacute (Upper Torrens) Dolomite of Howchin's type area. However, none of the cherty or magnesitic mud-curls so typical of that dolomite was noticed. Unfortunately the author reached this important area towards the end of a day's traverse and had no opportunity to revisit.

In the main Skillogalee Creek area no dolomite was found which could be correlated with the blue dolomites mentioned above, but the pale-blue dolomite which is the host of the secondary magnesite near Saddleworth may be comparable. In the Rhynie area (¾ N.W.) some 100 yards south of the Woolshed Flat road between section 210 and 557 Hundred of Alma a narrow band of cherty blue-grey dolomite occurs stratigraphically above a little pale-blue dolomite and much of the typical Skillogalee cream and white dolomite. It is below the Woolshed Flat Shale and Undalya Quartzite. In appearance and on analysis it closely resembles members of the Montacute (Upper Torrens) Dolomite (Table 1, No. 8, [No. 6 of map] and cf. Nos. 10 and 11). This dolomite which is thin-bedded and contorted is about 30 feet thick in this locality.

Hence, although the Skillogalee dolomites are characterized by cream dolomites, in several areas notable blue-grey members appear in the uppermost sections of the formations. No sedimentary magnesites were noticed.

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(1) An article by Mawson and Sprigg (1950) appeared several months after the script of this paper was in the hands of the Society, and certain changes in nomenclature have been made necessary. The formation names in parentheses are those appearing in papers previous to that by Mawson and Sprigg (1950).

(d) Woolshed Flat Shales

Light grey well-banded shales and sandy shales outcrop on the escarpment just north of the Woolshed Flat road one mile W.N.W. of Rhynie. Similar outcrops occur in most places where the Undalya Quartzite is able to protect these friable sediments. They are mostly too arenaceous to show either good slaty cleavage or drag folds.

Stratigraphically these shales include all the shales from the Rhynie Sandstone to the Undalya Quartzite. In most places the Rhynie Sandstone appears to pass almost directly into the Skillogalee Dolomite formation. Elsewhere, however, (particularly N.E. of Undalya) the Skillogalee Dolomite is a much narrower bed and is flanked on either side by several hundreds of feet of Woolshed Flat Shales.

(e) Undalya Quartzite

A large road-metal quarry has been cut in this formation at the bridge over the Wakefield at Undalya. The rock is a well-bedded medium-grained feldspathic white and cream quartzite, and occurs with numerous minor interbedded sandy, (?) carbonaceous and pyritic shales. In contrast to the Rhynie Sandstone this quartzite very rarely contains conspicuous bands of heavy minerals. The only noteworthy concentration was seen as numerous floaters (near in situ) near the crest of the eastern escarpment of the north pitching incline 3 miles N.N.W. of Rhynie. Crossbedding is not rare and slumping unknown, but graded bedding can be used to good effect as a sequence criterion. This quartzite was apparently laid down under more placid conditions that the Rhynie Sandstone—indeed the black pyritic shaly members suggest a partly stagnant environment.

The thickness of this formation is variable. A section along E-F through the Wakefield Reserve gave a minimum thickness of 2,500 feet. West of the Undalya the quartzites are shallow dipping and at least 2,500 feet thick. There is possible thickening on the noses of the pitching folds and the west limb of the regional north-pitching syncline is attenuated. In places it is only 500 feet thick.

Further east a sandstone occurs which has been mapped as the equivalent of the Undalya Quartzite. The Saddleworth Sandstone, as it could be called, forms a prominent ridge on the west side of the River Gilbert between Saddleworth and Riverton. Certain members are gritty, but it is characteristically a shaly sandstone, with considerable shaly intercalations. Sketch section C-D shows the proposed interpretation of its stratigraphic position, and further mention is made under the Auburn dolomites.

(f) Auburn Dolomites

Numerous dark-grey very fine-grained dense dolomites occur as bands some 18 inches to two feet thick within well-bedded blue-grey dolomitic silty shales and shaly sandstones which outcrop extensively near Auburn and between Riverton and Saddleworth. In the west the formation is divided by the Watervale Sandstone into upper (U.A.) and lower (L.A.) members: that is, in the deeper waters to the east of Riverton the sandstone has "lensed out" allowing the two dolomitic members to merge. The possibility of repetition by faulting of the Undalya Quartzite and the Lower Auburn Dolomites as the Watervale Sandstone and Upper Auburn dolomites (respectively) has not been overlooked. In the limited time for thie reconnaissance, however, no evidence for faulting was encountered and subsequent study of the air photographs suggests that the succession is normal.

A fairly good section may be seen near the main road from Auburn to Skillogalee. Cherty nodules with some limonitic pseudomorphs after marcasite are a feature of some of the dolomitic shales in the first big road-cutting west of Auburn. Some of the shales look carbonaceous and generally give the appearance of having been deposited in a quiescent poorly-aerated marine environment. (Similar features are well exposed in the first railway cutting on the Clare railway one mile from Riverton, and also in the banks of the Gilbert half a mile to the east.)

This road eventually passes down out of the Upper Auburn Dolomites into the Watervale Sandstone, the variable nature of which is well shown in the creek to the south of the road. Beneath the Watervale Sandstone the Lower Auburn Dolomites begin as several well formed bands interbedded in dark-grey dolomitic shales. An analysis (Table II, No. 12 was made of a two foot thick dolomite outcropping on the main road to Skillogalee 3¾ miles W.S.W. of Auburn (No. 7 of map).

Another analysis (No. 13, Table II) was made of a dolomite from the same formation where it outcrops in a small cutting on the main road 1½ miles south of Auburn (No. 8 of map). Here the rock is a laminated and somewhat contorted blue-grey dense fine-grained dolomite. There are considerable quantities of limonitic and pyritic pseudomorphs after marcasite.

In the Riverton-Saddleworth area the Lower and Upper Auburn Dolomites merge into one. Good exposures occur in road and rail cuttings in the vicinity of the two towns. An analysis is published (No. 14, Table II) of a typical dense dark-grey dolomite which outcrops near Saddleworth on a side road between Section 396 and 397, Hundred of Saddleworth (No. 9 of map).

It is apparent from Table II that the three new analyses are chemically very similar to typical members of the Beaumont Dolomites near Adelaide. In hand specimen and field associations they cannot be differentiated.

In the east bank of the Gilbert 200 yards south of the railway bridge which is one mile north of Riverton, there occurs a bed several inches thick of dull-white oolitic limestone interbedded with typical dense blue-grey dolomites and dolomitic shales.

(g) Watervale Sandstone

In the type locality alternating sandstones and sandy shales outcrop in a creek which runs parallel and south of the road to Skillogalee 3½ miles W.S.W. of Auburn. They may be seen to overlie stratigraphically the Lower Auburn Dolomites, and about 2½ miles from Auburn just south of the road may be found grading into the Upper Auburn Dolomites. The nearest suitable place name for these sediments is Watervale. To the west of this town the formation trends northward to Clare, where certain more arenaceous members are quarried as a freestone. Most of the sandstone members in this formation, however, contain a notable amount of clay, with plentiful detrital muscovite in many places. This tends to give the rock a good fissility. Detrital iron ores were not noted, but crossbedding and slumping are fairly common.

The formation becomes increasingly dolomitic both top and bottom as is passes, respectively, into the Upper and Lower Auburn Dolomites. It lenses out towards Riverton (which is "offshore") allowing the two dolomite sections to merge.

(h) Mintaro Shales

Between the Auburn Dolomites and the Gilbert Range Quartzites there is a large development of light-grey, blue-grey and light-fawn shales. Their ready disintegration into a rich soil has controlled the location of the best

wheat farms in the area. Natural outcrops are poor and considerable difficulty was encountered in choosing a type section. Reasonable exposures exist along the Section A-B but considerable thinning by squeezing between massive arenites is apparent. Another section along F-G is not so good and strike faulting may occur beneath the plentiful soil cover.

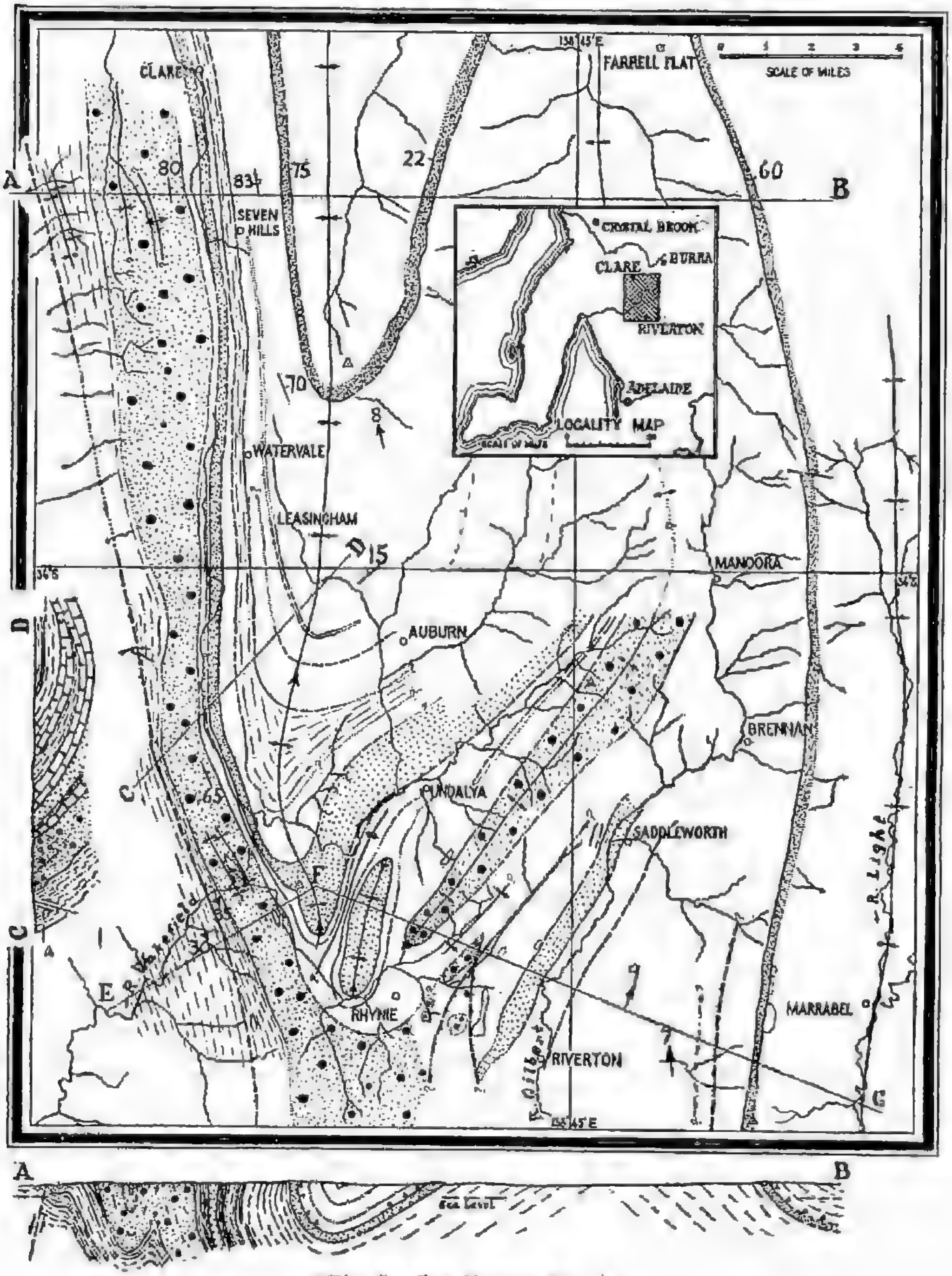

Fig. 2. See Key to Fig. 1

The *lower half* of the formation consists of a pale blue-grey calcareous shale with minor silty and arenaceous members. Slaty cleavage was rarely noted. The *upper half* is more argillaceous but is still notably calcareous in places. No limestone members, however, were discovered. Slaty cleavage is fairly well developed in the Clare region but elsewhere is poorly shown. The shale, of light-fawn and light-grey colour, has a marked banding not unlike that of the Glen Osmond Slates near Adelaide, and the slight difference in grain size renders it distinctly varvoid.

In this connection it is significant to recall that Jack recorded that occasional pebbles have been taken from the Mintaro slate quarries, and suggested that it may indicate a relation to the Sturtian tillite. Mapping now shows that the shales at Mintaro are close to the base of the Gilbert Range Subglacial Quartzites. If Howchin's correlation with Tapley's Hill Slates were to be correct they should occur above the quartzites.

Occasional narrow quartzite bands occur as members within the Mintaro Shales. The best developed has been called the Leasingham Quartzite member. This fawn feldspathic medium-grained sandstone is best seen on the crest of a low rise west of Auburn in Section 288, Hundred of Upper Wakefield. A small buff sandstone was observed in a contorted area in main road cutting 3½ miles east of Riverton (Section 467, Hundred of Gilbert)

Two major quarries have been opened in the Mintaro Shales. One and a half miles N. of Auburn (Section 216, Hundred of Upper Wakefield) is a large "slate" quarry which has produced a good building stone (Jack 1923, p. 35). Stratigraphically it is about 1,000 feet above the base of formation. A more important group of quarries exists about one mile west of Mintaro where a laminated shallow dipping blue-grey shale yields high-grade large "slate" slabs and flagstones (ibid, p. 28). Stratigraphically these shales are very high in the formation and soon give way to the Gilbert Range Quartzites and associated glacial sediments.

(i) Gilbert Range Quartzites [2]

These white feldspathic quartzites (or sandstones) comprise a major mapping unit in this area. They are resistant to weathering and form fair outcrops which can be traced for many miles by means of aerial photographs. Immediately above the major and uppermost sandstone (there may be two or more minor, probably lenticular, sandstone members) a tillite and associated fluvioglacials occur. Owing to the ready erosion of the tillite a careful search for shed erratics may be necessary to confirm the identity of this key sandstone formation.

Both Howchin (1927) and Segnit (1945) describe these sandstones as occurring beneath the "Sturtian tillite" three miles west of Kapunda, a few miles south of the area under discussion. Hossfeld (1934) was able to trace this "subglacial quartizite" from the Tanunda area to the Gilbert Range.

In the time available the only section actually measured over this formation was that to the S.E. of Clare along Section A-B. Here the Mintaro Shales give way suddenly to a 2 foot-thick white feldspathic sandstone. Then follows about 300 feet of shale and sandy shale identical with the Mintaro Shales below. Then occurs the major arenite (about 250 feet)[3], a dense white feldspathic sandstone. Its resistant nature results in the prominent delineation of the north-pitching syncline on the nose of which is Mount Horrocks. No pebbles were seen in this sandstone.

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(2) This formation name seems to have been first used by Hossfeld (1934) in his sketch section on p. 48.

(3) Unfortunately, during removal from South Australia the author's last field notebook became displaced, hence only data already transferred at that time to the master plan and drawn sections could be used for estimation of thicknesses along A-B.

(j) Glacial and Fluvioglacial Sediments

It was only in the last stages of the reconnaissance that these were discovered in the Clare region and the work had to be discontinued before the group could be properly studied. The only section studied in any detail was that along A-B. On top of the Gilbert Range Quartzites about 400 feet

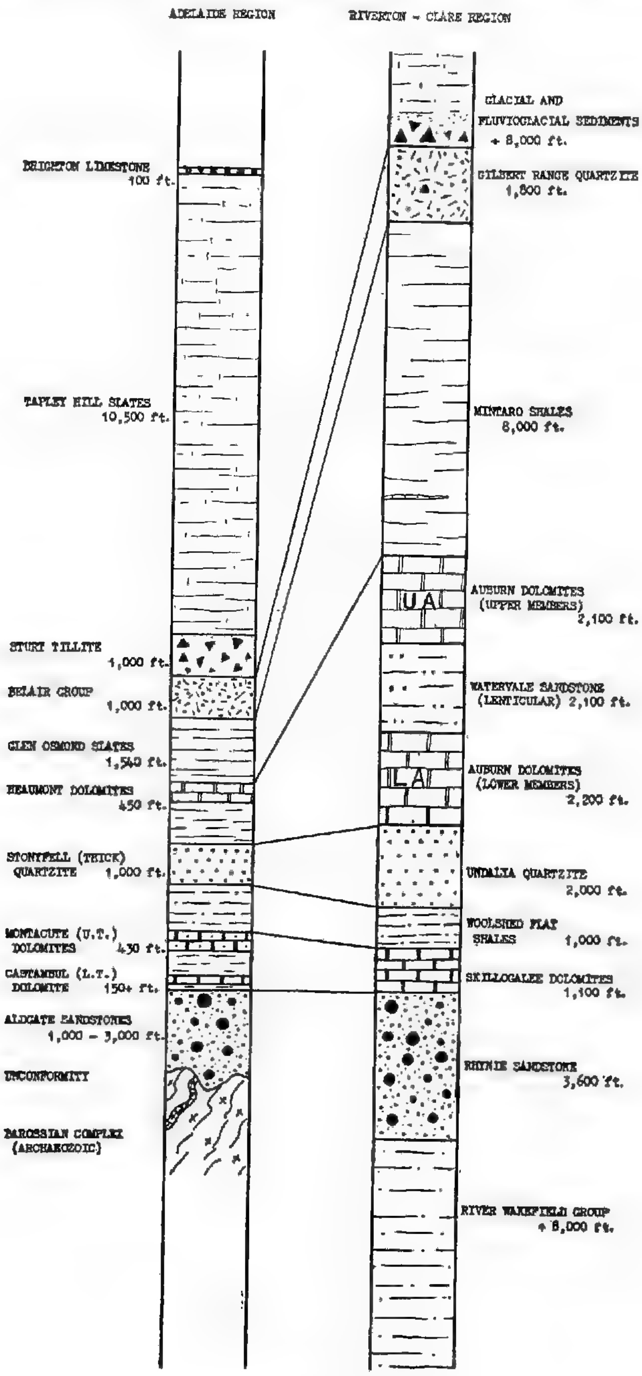

Fig. 3

of blue-grey sandy laminated shale occur. This is followed by ten feet of fluvioglacial grit and about 300 feet of non-bedded and poorly-bedded light-grey tillite. Erratics of granite and gneiss are common and outnuumber those of quartzite in this area. Occasional glacial striae were observed. Above the tillite is an unknown thickness of well-laminated blue-grey sandy shales and normal shales. After about 800 feet they pass under cultivated land reappearing on the east flank of the syncline some three miles away. It is suspected that this large group of sediments is predominantly fluvioglacial.

(2) Correlations

Figure 3 illustrates the main features of correspondence between the Riverton-Clare region and the type area near Adelaide. However, a few features need comment.

(a) River Wakefield Group and Rhynie (ilmenitic) Sandstone

The ilmenitic sandstones of the type area are usually found unconformably overlying the Older Precambrian metamorphic rocks as at Aldgate. In the Riverton-Clare region, however, field work now indicates that a great thickness of sediment lies comformably beneath a comparable ilmenitic sandstone, the Rhynie Sandstone. This reminds one of Sprigg's 1945 record of of a new group of alternating shales and sandstones in the Torrensian (Lower Adelaide) series. He tentatively placed the new group above the "basal" ilmenitic sandstone but was uncertain of the true stratigraphic position. Recent work by geologists of the South Australian Geological Survey seems to indicate that a large group of shales and sandy shales lies conformably *beneath* an ilmenitic sandstone in several parts of the Mt. Lofty Ranges. (R. C. Sprigg, verbal communication, July, 1949.)

In addition, the author recalls that some of the feldspathic ilmenitic sandstones of the Warren Reservoir area apparently are stratigraphically above a considerable thickness of metasediments of a type corresponding to the River Wakefield Group. Similarly, at the Little Gorge, Normanville, a coarse ilmenitic feldspathic sandstone has been overturned but stratigraphically overlies phyllonitic and schistose rocks in a conformable manner. Thus the unconformable break at the base of the late Proterozoic sediments is not at the base of the ilmenitic sandstone in all cases as at Aldgate and West Humbug Scrub. It seems likely that "the original Archaeozoic floor to the geosyncline was uneven, presenting a sedimentary environment of the Archipelago type. In this manner rapid variations in sediment type and thicknesses of basal or near basal units would be expected. As more sediments accumulated on the sinking geosynclinal floor the effects of the original topographic irregularities would be neutralized." (Sprigg 1946, p. 328.)

(b) Skillogalee Dolomites

The cream Skillogalee Dolomites may be compared with the dolomites of the Torrens Gorge, which comprise the cream-colored Castambul (Lower Torrens) Dolomite, phyllites, and the blue-grey Montacute (Upper Torrens) Dolomites. Of these, the Montacute (Upper Torrens) Dolomite is more important that the Castambul (Lower). In the Riverton-Clare region, however, the bulk of the Skillogalee Dolomite formation comprises cream dolomites; phyllites are nearly absent and relatively meagre blue-grey dolomites occur only near the top of the formation and only in some localities. Sedimentary magnesites were not recognised.

(c) The AUBURN DOLOMITES (bifurcated in the west) follow the Undalya Quartzite which is correlated with the Stonyfell (Thick) Quartzite. Analyses in Table II indicate the remarkable chemical similarity of these dolomites and the Beaumont Dolomites which are not so extensively developed in the Adelaide region. Sedimentary magnesites were not recognised.

(d) The MINTARO SHALES, GILBERT RANGE QUARTZITES and glacial and fluvioglacial sediments are probably contemporaneous with the Glen Osmond Shale, the Glen Osmond Quartzite and Sturtian Tillite of the type area.

About 9,000 feet of sediments have been recorded in the Torrensian (Lower Adelaide) Series in the type area (Mawson and Sprigg, 1950, p.71). The Riverton-Clare region gives an approximate measure of the order of 30,000 fet. This estimation will undoubtedly be modified on completion of detailed mapping but it nevertheless indicates a remarkable increase in this region.

Concerning the Flinders Ranges Sprigg (1946, p. 328) has suggested that Mawson's Magnesite Series (Mawson, 1941) is contemporaneous with the Torrens Dolomites. The mapping in the Riverton-Clare region appears to confirm this view. The remarkable development of sandstone and conglomerate (in part ilmenitic), so consistently found beneath the Magnesite Series, is considered by Mawson (1947) to be the basal formation of the Proterozoic sequence (in the Flinders Ranges). However, in view of this recent mapping the author is not happy about this conclusion. The large development of the River Wakefield Group must be taken into account, and need for careful investigation of the Clare-Spalding area is indicated.

Hossfeld in his extensive work on the north-eastern Mt. Lofty Ranges (1934) has suggested fundamental changes in the Adelaide Series as first described by Howchin. Two unconformable series are erected, viz., the Para and the Narcoota Series. Hossfeld's Para Series appears to correspond fairly well with the Torrensian (Lower Adelaide) Series as now defined by Mawson and Sprigg (1950); it outcrops in the Adelaide region and to the west of the Humbug Scrub Archaean block and continues north of Gawler. Like the Para Series, the Narcoota Series has a basal ilmenitic sandstone, but this is thought by Hossfeld to correspond to the Glen Osmond Quartzites. The sequence above this "basal" sandstone is reasonably comparable with the Sturtian (Middle Adelaide) Series of the type area. In the Clare region, however, a complete sequence (*without* unconformity) is indicated from the lowest parts of the Adelaide System (Hossfeld's Para Series) up through the Gilbert Range Quartzite into a tillite and the equivalent of Tapley's Hill Slates. These upper formations are in Hossfeld's Narcoota Series, and the Gilbert Range Quartzites which were used as a marker bed in this area have been traced south as far as Greenock which is near the centre of Hossfeld's map. His map, however, does not clearly show the relation of this important bed to the ilmenitic "basal" Narcoota beds near by, nor has the ilmenitic sandstone been discovered north of Greenock in proximity to the Gilbert Range Quartzites.

Grave difficulties of this type arise when an attempt is made to integrate Hossfeld's broader findings and those on the western margins of the geosyncline.

II. TERTIARY

(a) *Laterite* has been observed in a few places on the eastern side of the Gilbert Range. It has formed over sandstone and tillite on a gentle easterly-

dipping poorly-peneplaned landsurface. This material was probably formed during Miocene or Pliocene times.

(b) Numerous *coarse conglomerates* occur as remnant aprons along the Alma Fault Scarp, which appears to have been a prominent physiographic feature from (at least) early Pleistocene.

B. TECTONICS

Sprigg (1946) has already outlined the broader features of the Palaeozoic orogeny as it affected the Mt. Lofty Ranges, particularly near Adelaide. In that region both folding and faulting were much more intense than in the Riverton-Clare area.

In this area the Proterozoic sediments were thrown into a series of meridionally trending folds of considerable magnitude. The peculiar variation in trend of fold axes, and the variation of dip of axial "planes" suggests that pure compressional force from the east would be an insufficient cause for the fold pattern. In the map the trend lines of the Gilbert Range Quartzites, the Undalya Quartzite and the Rhynie Sandstone indicate that in the Clare region there is a major drag on the normally meridional fold axes. This has been brought about by movement of the western area (near Blyth) southwards and downwards relative to the eastern areas (near Waterloo) which have apparently moved northwards and upwards. This would account for the prevailing shallow northerly pitch of the major folds. Further, the strange basin structure west of Rhynie and north-easterly trending S.-W. pitching anticline to the west of Undalya are to be expected from such relative movements near the nose of the major drag.

Palaeozoic faulting is less important in the Riverton-Clare region than in the vicinity of Adelaide. The faulting does not appear to interrupt the section to any great degree. There appears to be a normal fault on the west side of the Gilbert Range. Minor silver-lead-copper mineralization took place along this zone of weakness.

A fault has been postulated between Rhynie and Riverton. On stratigraphic evidence the east block has been downthrown about 1,000 feet. The most important fault zone in the area is the Alma Fault (so named from its appearance in the Hundred of Alma). Later movement in the Kosciusko phase (late Tertiary) has given rise to the notable fault scarp which forms the western margin of the Ranges proper. Abundant cellular quartz floaters occur in proximity to the fault zone and suggests that it was an original reverse fault which has in more recent times reopened as a normal fault. Time was not available to study criteria in the field, but Sprigg (1945) has pointed out similar phenomena in the Adelaide region.

C. ECONOMIC GEOLOGY

No Palaeozoic granite occurs anywhere in the area, and the degree of regional metamorphism is negligible. Small *silver-lead-copper* sulphide vein-fillings occur in association with the Gilbert Range fault zone. An old copper mine is reported in a blue-grey dolomite about six miles west of Rhynie near the River Wakefield (Section 275, Hundred of Alma).

Numerous small *auriferous quartz veins* occur meridionally throughout the Rhynie Sandstone and other arenites, especially in the Clare region where the folding has been more intense. These may well represent concentrations in "gash veins" of detrital gold in the sandstones. In themselves none is payable, but most of the meagre gold of the area has been won from associated alluvial deposits. The Mintaro area has produced most gold, and

prospectors have found small amounts in many places along the Wakefield and its major tributaries.

Talc is often found in small quantities in crests of tightly folded anticlines in the Skillogalee Dolomites (e.g. road metal quarry ¾ mile W.N.W. of Rhynie).

Magnesite was obtained as a valuable by-product of a dolomite road metal quarry at Saddleworth. It occurs in the blue sections of the Skillogalee Dolomite, and probably represents the Montacute (Upper Torrens) Dolomite which is noted elsewhere for its weathering to magnesite, and (in the Flinders Ranges) for its sedimentary magnesite members. No payable sedimentary magnesites have been discovered in this area.

Road Metals—Quarries are found in all of the major arenaceous formations. The Skillogalee Dolomites are a popular stone, especially in the Rhynie area.

Building Stones—R. L. Jack (1923) has described the major building stones of the area. Freestones are plentiful—indeed most of the feldspathic arenaceous formations have been quarried with varying success for this purpose.

Highgrade *flagstones* or *slates* are still quarried at Mintaro. These occur high up in the thick Mintaro Shale formation which appears to be the equivalent not of the Tapley's Hill Slate but of the Glen Osmond Shales. A large quarry exists in the same formation north of Auburn. Other formations have had limited use in several towns in the district.

In the latter stages of this reconnaissance a group of senior students of the University of Adelaide assisted in the Rhynie area. Outstanding among these were Messrs. Rowley, Reynolds, Dore, Lowe and Richardson. Mr. R. C. Sprigg was able to arrange through the South Australian Mines Department for nine partial analyses of dolomites to be undertaken. Some of the drafting costs were met by Commonwealth Research Grant administered by the University of Western Australia.

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THE MORPHOLOGICAL DEVELOPMENT OF THE EMBRYO OF GRYLLULUS COMMODUS WALKER (ORTHOPTERA: GRYLLIDAE)

BY HELEN M. BROOKES

Summary

The embryo arises on the dorsal surface of the egg near the posterior pole. After 48 hours at 25.2ºC it is completely immersed in the yolk and becomes greatly convoluted and twisted. In the pre-revolution stages it is separated from the yolk dorsally by a membrane. After revolution the embryo is closed dorsally by the amnion while engulfment of yolk into the mid-gut proceeds. Definitive dorsal closure takes place after about 9½ days. A cuticle is secreted over the entire surface of the body and is shed shortly after eclosion. The development of body form in embryos incubated for specified periods is described and illustrated.

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[Read 8 November 1951]

SUMMARY

The embryo arises on the dorsal surface of the egg near the posterior pole. After 48 hours at 25·2°C. it is completely immersed in the yolk and becomes greatly convoluted and twisted. In the pre-revolution stages it is separated from the yolk dorsally by a membrane. After revolution the embryo is closed dorsally by the amnion while engulfment of yolk into the mid-gut proceeds. Definitive dorsal closure takes place after about 9½ days. A cuticle is secreted over the entire surface of the body and is shed shortly after eclosion. The development of body form in embryos incubated for specified periods is described and illustrated.

During blastokinesis the embryo twice passes about the posterior pole of the egg. Revolution of the embryo is defined and described in the living egg. It occurs after 6½ days' incubation at 25·2° C. and is achieved without apparent active movements of the embryo.

The eclosion of the nymph from the egg and from the embryonic cuticle is described.

INTRODUCTION

During experimental studies of the biology and ecology of *Gryllulus commodus* now being made at this laboratory (Browning, 1952), the need has arisen for some knowledge of the morphological development of the embryo in a controlled environment. In this paper the movements of the embryo during blastokinesis and the development of the external form of the embryo are described for diapause-free eggs which were incubated in damp sand at a constant temperature of 25·2°C.

MATERIAL AND METHODS

About 200 adult crickets were collected in March, 1950, from cracks in soil at the Waite Institute and put into cages containing trays of clean, damp sand. When it became apparent that the females were ovipositing freely fresh trays of sand were introduced into the cage and at the end of one hour these were removed, the eggs sieved out under water and fixed within half an hour. Similarly, eggs not more than four and a half hours old were obtained and fixed. These served for the study of the very early stages.

A large number of eggs not more than eight hours old were obtained in this manner and these were placed in damp sand at 12·8°C. for 30 days to permit the completion of diapause (Browning, 1952). At the end of this period these eggs were transferred to a thermostat held at 25·2° C. A sample of about 100 eggs was taken from these at the time of transfer to the incubation temperature and further samples were taken at intervals of 8 hours thereafter for 3½ days. After this samples were taken every 24 hours until hatching occurred after 16½ days. These eggs served for the study of all but the early stages of development (0 to 8 hours old).

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There were in all twenty-three samples of eggs fixed, representing 23 different stages. It was not practicable to assess a mean stage of development for a sample but it was comparatively easy to recognise a modal stage of development for each group, i.e. the stage which had been reached by the majority of embryos in the sample. This stage was taken as characteristic; the twenty-three stages which were determined in this way have been illustrated in figure 3 and numbered 1 to 23 for easy reference elsewhere in the text. Similarly a number of stages in blastokinesis were recognised. These have been illustrated in figure 1 and designated by the letters A to R.

In any sample of eggs the modal group was quite well defined, usually including more than half the eggs, but there were always some embryos lagging behind. Sometimes there were a few in advance of the stage reached by the majority. In this the eggs resemble those of the grasshopper *Melanoplus differentialis* (Slifer, 1932b). For example, in a sample of sixty-five eggs incubated for 4½ days at 25·2°C., forty-nine had reached the same stage of development (figure 3, stage 11), four were in stage 10, five in stage 8, two in stage 7, while five were one day in advance (stage 12). The variability found in each sample is shown in Table I below.

TABLE I.

Showing the distribution of development in samples of eggs incubated for specified periods at 25° C. The embryos have been classified into three classes: (a) those behind the modal stage of development, (b) those in the modal stage, (c) those in advance of the modal stage.

Time at 25.2°C	Percentage eggs Stages behind	Modal stage	Stages ahead	Time at 25.2°C	Percentage eggs Stages behind	Modal stage	Stages ahead
0 hours	36	45	18	6½ days	23	48	29
8 ,,	15	81	4	7½ ,,	33	67	—
16 ,,	26	55	19	8½ ,,	34	49	17
24 ,,	18	71	11	9½ ,,	44	56	—
32 ,,	60	40	—	10½ ,,	21	79	—
40 ,,	42	58	—	11½ ,,	8	92	—
48 ,,	58	42	—	12½ ,,	7	93	—
56 ,,	52	48	—	13½ ,,	6	94	—
64 ,,	67	33	—	14½ ,,	2	98	—
3½ days	37	63	—	15½ ,,	3	97	—
4½ ,,	17	75	8	16½ ,,	7	93	—
5½ ,,	21	79	—				

After dissolving the chorion from the shell in a 3 per cent. solution of sodium hypochlorite, according to the method described by Slifer (1945) the eggs were fixed in Bouin's picro-formol in a water bath at 60°C. for twenty minutes. Whole eggs were stained in bulk in aqueous borax carmine (Grenacher's) for from one to twenty-four hours and destained in acid alcohol (0·5% HCl in 70% alc.) for from one to two weeks. It was found necessary to slice the shell in the region of the embryo to allow penetration of the stain. Sections were cut at 6 μ and 8 μ, stained in Mayer's acid haemalum and in Delafield's haematoxylin, and counterstained in aqueous eosin.

All drawings were made using a camera lucida.

OBSERVATIONS

The Egg

When first laid the egg of *Gryllulus commodus* is about 2 mm. long, slender, slightly convex dorsally and tapering towards the posterior pole.

The shell consists of a semi-opaque chorion at first, but a tough transparent cuticle is laid down below the chorion very soon after the egg is laid and this increases in thickness for some time. A transverse line of weakness in the cuticle near the anterior end indicates the junction of the "cap" which is usually pushed off during eclosion. A smaller cap occurs at the posterior end; it is possible that this covers the micropylar area, although the micropyles were not observed. The length of the egg may increase by about fifty per cent. by the time the embryo is ready to hatch.

The yolk is finely granular. A central longitudinal "core" is apparent in eggs 1½ hours old and persists for at least sixteen hours. It is straight when viewed anteriorly but curves towards the ventral surface at the middle of the egg. This resembles the "condensation cytoplasmique interne" described by Darbois (1950) in *Gryllus campestris, G. bimaculatus* and *G. bermudensis.* In transverse sections of eggs up to 1½ hours and 4½ hours old the "core" is seen to consist of yolk particles that are smaller than the surrounding yolk. Later, the yolk particles become grouped into larger polyhedral masses.

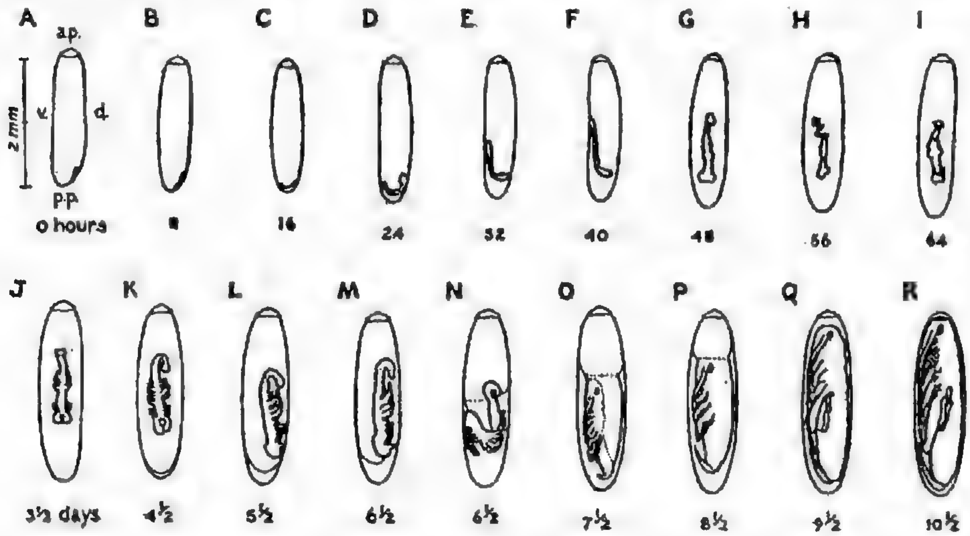


Fig. 1
Stages reached by the embryo of *G. commodus* during blastokinesis when incubated at 25·2° C. for varying periods.

Blastokinesis

The term *blastokinesis* refers to all the movements of the embryo by which it changes orientation in the egg. Two stages in blastokinesis have been recognised—anatrepsis and katatrepsis. During anatrepsis the embryo moves tail first towards the anterior end of the egg; during katatrepsis it moves head first towards and around the posterior pole and then ascends towards the anterior pole. *Revolution* is the term used by Wheeler (1893) and adopted here to describe that part of katatrepsis in which the embryo ruptures the amnio-serosa and revolves around the posterior pole (fig. I, stages M-O and plate 1).

Anatrepsis

The embryo of *G. commodus* is of the immersed type. It arises on the dorsal surface of the egg near the posterior pole. During the first 16 hours the embryo moves tail first around the posterior pole, usually in a superficial

position (stages A-C). Gradually it sinks into the yolk until, by the 40th hour, only the most posterior part remains at the surface (stages D-F). By the 48th hour it has become immersed (stage G). Once free in the yolk the embryo moves towards the anterior pole; in some cases the tail may reach about one-fifth of the length of the egg from the anterior pole. Irregular convolutions along its length and a spiral twisting suggest that the embryo is capable of vigorous movement (stages H-I). Eventually it straightens out except for the posterior abdominal segments and its ventral surface comes to face the dorsal surface of the egg (stage L). Such activity renders it difficult to determine at what point anatrepsis ends and katatrepsis begins; certainly the embryo has begun katatrepsis by the end of 4½ days (stage K).

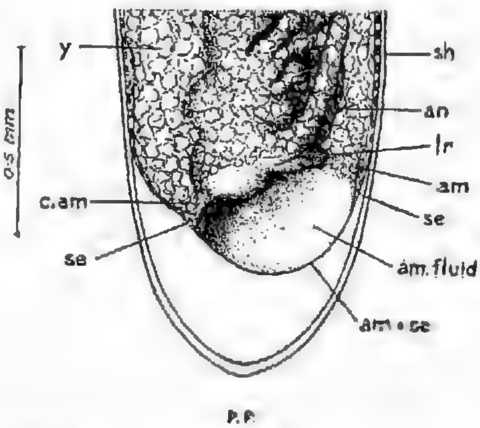


Fig. 2

Posterior portion of the egg of *G. commodus* showing the embryo about to revolve around the posterior pole. am, amnion; am + se, amnio-serosa; an, antenna; c.am, cephalic amnion; lr, labrum; P.P., posterior pole; se, serosa; sh, shell; y, yolk.

Katatrepsis

During katatrepsis the yolk contracts from the posterior pole, leaving a clear space filled with fluid. As the embryo advances toward the posterior pole a translucent area appears on the dorsal side of the egg where the yolk is apparently being liquefied between the amnion and serosa. At 6½ days the space between the yolk and the posterior pole occupies about one-sixth of the length of the egg (stage M). The amnion fuses with the serosa to form the amnio-serosa which is at this stage greatly distended with amniotic fluid. The embryo is ready to revolve when the protocephalic lobes are visible through the transparent amnio-serosa at the posterior boundary of the yolk (fig. 2).

Revolution

Revolution of the embryo was observed at room temperature in several living eggs from which the chorion had been dissolved. An embryo in the stage shown in Fig. 2 took about three hours to move into a position where the protocephalic lobes and labrum press against the amnio-serosa. So great was this pressure that the labrum was forced back against the body and the amnio-serosa stretched into a deep bulge by the protocephalic lobes. After about thirty minutes the labrum suddenly swung downward, indicating that the amnio-serosa had been ruptured. Revolution proceeded rapidly in the earlier part. Within five minutes the protocephalic lobes, antennae and mouthparts had in turn emerged from the yolk into the amniotic fluid at the posterior pole. The yolk had contracted by about one-quarter of the length of the egg. Revolution is completed when the ventral surface of the embryo faces the ventral surface of the egg and the abdomen has straightened out (stage O). The whole process of revolution was completed in about twelve hours (plate ix).

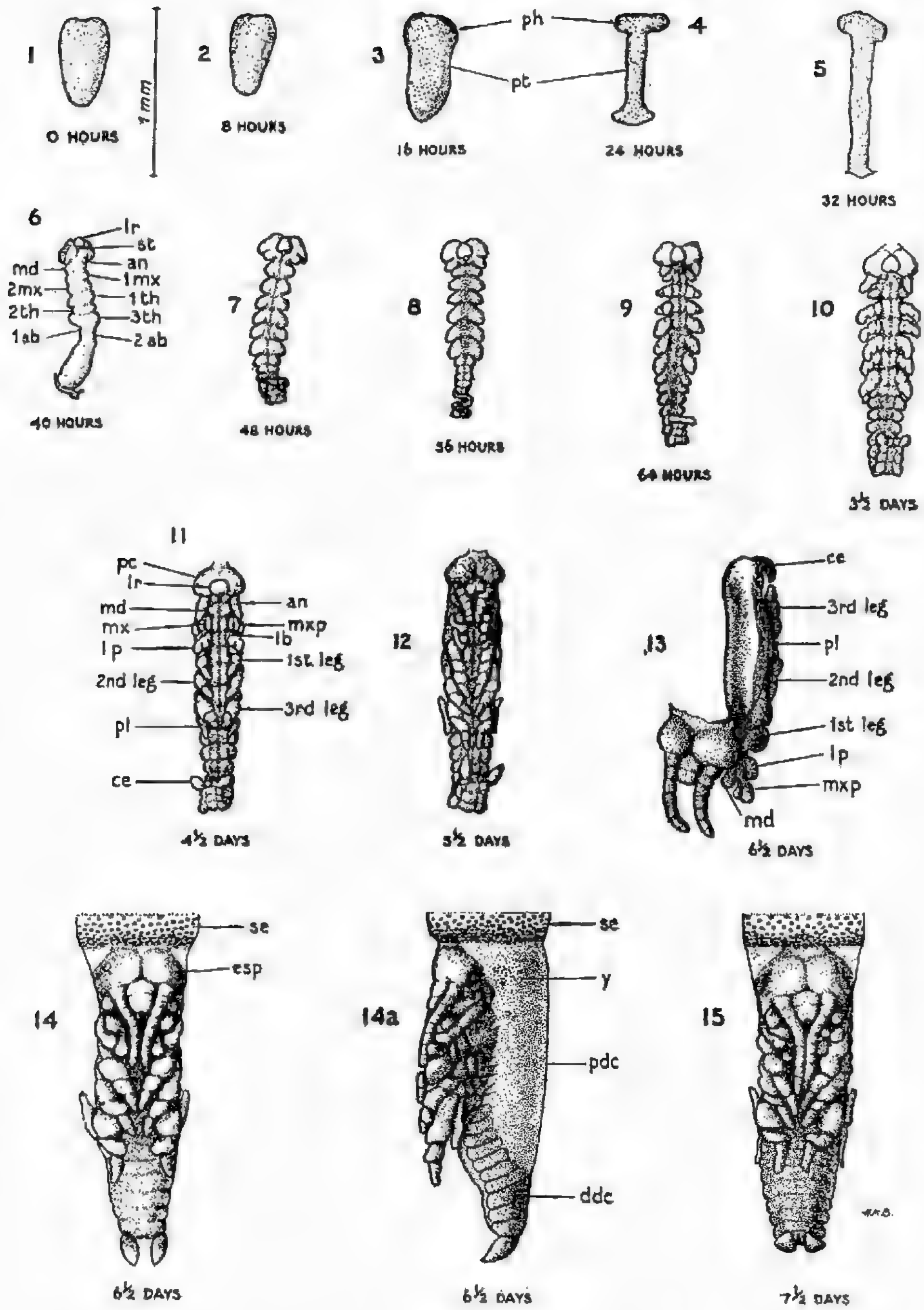


Fig. 3

The development of body form in the embryo of *G. commodus*. Each stage corresponds to the stage in Fig. 1 incubated for the same period. Stage 13 represents an embryo in the course of revolution, from which the yolk has been dissected away. Fig. 14a is the lateral view of stage 14. All stages drawn to scale.

ab, abdominal segment; an, antenna; ce, cercus; ddc, definitive dorsal closure; e, eye; esp, eye-spot; lb, labium; lp, labial palp; lr, labrum; md, mandibular segment; mx, maxillary segment; mxp, maxillary palp; pc, protocephalic lobe; pdc, provisional dorsal closure; ph, protocephalic region; pl, pleuropodium; pt, protocormic region; se, serosa; st, stomodaeum; th, thoracic segment; y, yolk.

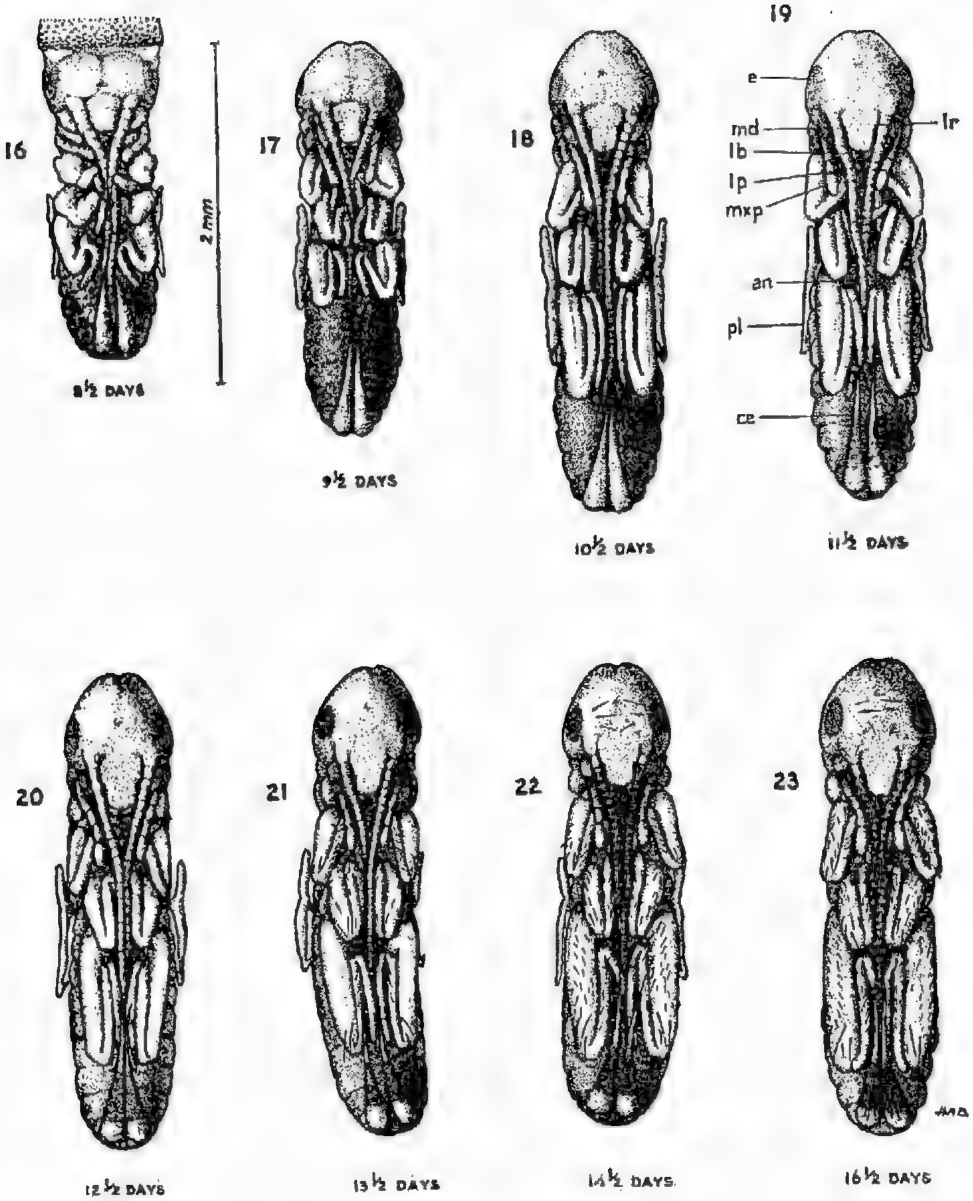


Fig. 3 *(continued)*

No active movements of the body walls or appendages were observed during revolution. In this *G. commodus* differs from *Melanoplus differentialis* in which revolution is accomplished by vigorous movements of the embryo (Slifer, 1932a).

In the final stages of katatrepsis the embryo continues to move towards the anterior end of the egg while growing in length until the head reaches the anterior pole (stages P-R). Thus, during blastokinesis, the embryo has twice passed about the posterior pole of the egg.

Eclosion

The head of the embryo pushes against the anterior end of the egg until the cap is forced off and the insect emerges. Alternatively, a split in the shell may occur in the region of the back of the head. As the embryo heaves the split is enlarged and the thoracic segments emerge, followed by the head and antennae. The body bends backward and forward until the insect is freed. The teeth on the chitinous armature of the labrum do not appear to aid hatching (c.f. Cappe de Baillon, 1922).

Immediately after eclosion the nymph casts off the embryonic cuticle. This is accomplished by vigorous expansion and contraction of the body, causing a split in the cervical region. Rhythmical contractions begin in the cerci and sweep upward so that the cervical vesicle collapses, the vertex and labrum expand, and the vesicle expands. The tear increases in length. Gradually the thorax and head are withdrawn and the appendages unsheathed. Finally the embryonic cuticle is kicked off by the hind legs and the nymph is free.

Development of Body Form

Embryos taken from the sample of eggs which have been stored at 12·8°C. for 30 days are about 0·05 mm. long, roughly pear-shaped with an anterior median notch, and slightly convex (fig. 3, stage 1).

After incubation for 16 hours a constriction forms which divides the embryo into a protocephalic and a protocormic region. Soon protocephalic lobes appear; they expand laterally and begin to curve backward (stage 4). The protocormic region, or "tail" lengthens until the embryo is about half to two-thirds as long as the egg (stage 5).

Primary segmentation of the embryo begins after 32 hours' incubation and proceeds gradually from the anterior to the posterior end (stage 6). By the time the embryo has become immersed in the yolk (48 hours) primary segmentation is complete. The labrum has developed into a globular swelling between the protocephalic lobes, leaving the stomodaeum exposed; the antennal, mandibular, two maxillary, three thoracic and eleven abdominal segments have become demarcated. The embryo apparently decreases in length due to convolution and ventral flexure of the posterior abdominal segments, but it begins to widen as secondary segmentation takes place (stage 9).

The appendages of the first and eleventh abdominal segments persist as pleuropodia and cerci respectively. The pleuropodia are of the evaginate type; they develop as long, slender, glandular structures arising laterally from the pleural membrane of the first abdominal segment by means of a narrow stalk (plate x, fig. C). The cerci develop into slender conical structures lying close to the ventral wall of the body.

After incubation for 5½ days, when the embryo is approaching revolution, the appendages have assumed their characteristic form. The labrum, which has grown downward to conceal the stomodaeum, shows a transverse groove in the middle and a median notch on the posterior margin. The posterior abdominal segments remain flexed forward. The embryo at this stage occupies about half of the length of the egg (fig. 1, M).

After revolution is completed the embryo has increased greatly in thickness due to partial engulfment of the yolk; about half of the yolk is enclosed after incubation for 6½ days (fig. 1, O and fig. 3, stage 14). At this stage the free margins of the body wall begin to fuse in the mid-dorsal line.

beginning at the posterior end. The first traces of eye-pigment appear as an orange streak. The abdomen straightens out, with the cerci lenthening and lying along the ventral surface of the body. The yolk is completely engulfed after 9½ days, when the embryo has grown to occupy about seven-eighths of the length of the egg. A cuticle is secreted by the embryo over the entire surface of the body at this stage so that the appendages are enveloped individually. The eyes are pigmented light brown with their margins clearly defined. A pair of fine black lines marks the chitinous thickening in the embryonic cuticle at the lateral margins of the labrum. The pleuropodia have grown to about one-quarter of the length of the embryo (plate x, fig. d). The embryo has attained its full length after about 10½ days' incubation.

Changes occurring during the next six days consist mainly of increasing differentiation and pigmentation of the body parts. An embryo incubated for 11½ days (stage 19) shows light brown pigmentation of the labrum. A transverse reddish-brown band appears on the cerci. By the end of 14½ days' incubation pigmentation in the head region is extensive. The chitinous armature of the labrum bears numerous forwardly-projecting teeth and is equally developed on each lateral margin. In this *G. commodus* resembles *Gryllus campestris* and *Gryllomorpha dalmatina* but differs from *Nemobius sylvestris* in which the armature is fully developed only on the right side (Cappe de Baillon, 1922). An embryo incubated for 16½ days is ready to hatch. The head and face are mottled light brown, the eyes black, the mandibular teeth reddish-brown and the lateral margins of the labrum black. All the spines and bristles that invest the embryo may be seen adpressed flat beneath the transparent embryonic cuticle. Fine black bristles encircle the antennal segments, giving them a uniformly dark appearance, and strong black spines outline the legs. The posterior abdominal segments are pale reddish-brown with a brown band across the cerci. Rows of black bristles occur dorsally on the anterior and posterior margins of the thoracic segments. A row of brown bristles marks the posterior margin of each abdominal segment.

Dorsal Closure

The embryo in the pre-revolution stage is separated from the yolk dorsally. When a living embryo was dissected from the egg in Ringer's solution a delicate membrane was observed extending over the dorsal surface in a manner resembling the ventral amnion. It appears to extend from the blind end of the stomodaeum to the proctodaeum, but was not seen posterior to this. In section the membrane is seen enclosing non-cellular material abutting on the inner side of the embryo and forming an intact barrier to the yolk (plate x, fig. a). This structure resembles the "ental membrane" described by Miller (1940) in the embryo of the stonefly *Pteronarcys proteus* and that described by Roonwal (1937) as the "first provisional dorsal closure" in *Locusta migratoria*. It is not known at which stage in *G. commodus* the membrane is laid down.

At the time when revolution has just been completed the body walls have met in the mid-dorsal line and "closed" the embryo in the posterior fifth of the body. For the remainder of its length it is still trough-like (fig. 3, stage 14a). The inside surface of the embryo is covered by the membrane described in the preceding paragraph. The amnion, having turned inside out, now forms a temporary dorsal wall of the embryo ("second provisional dorsal closure" of other authors). The space between these two membranes is the incipient mid-gut and it now contains about half of the yolk (plate x, fig. b). The true body walls continue to grow around the incipient mid-gut

beginning at the posterior end and meeting in the mid-dorsal line to complete the definitive dorsal closure of the embryo. The final stage in this process is illustrated in fig. 4. It occurs after about 9½ days' incubation at 25·2°C.

Active movement within the embryo is seen for the first time at stage 14. Waves of contraction which seem to be initiated at the posterior end surge upward along the free lateral margins of the body wall to the head. The abdominal segments expand and contract rhythmically. The appendages do not exhibit independent movement.

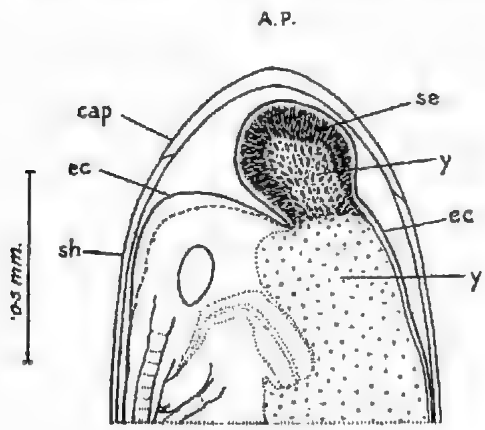


Fig. 4

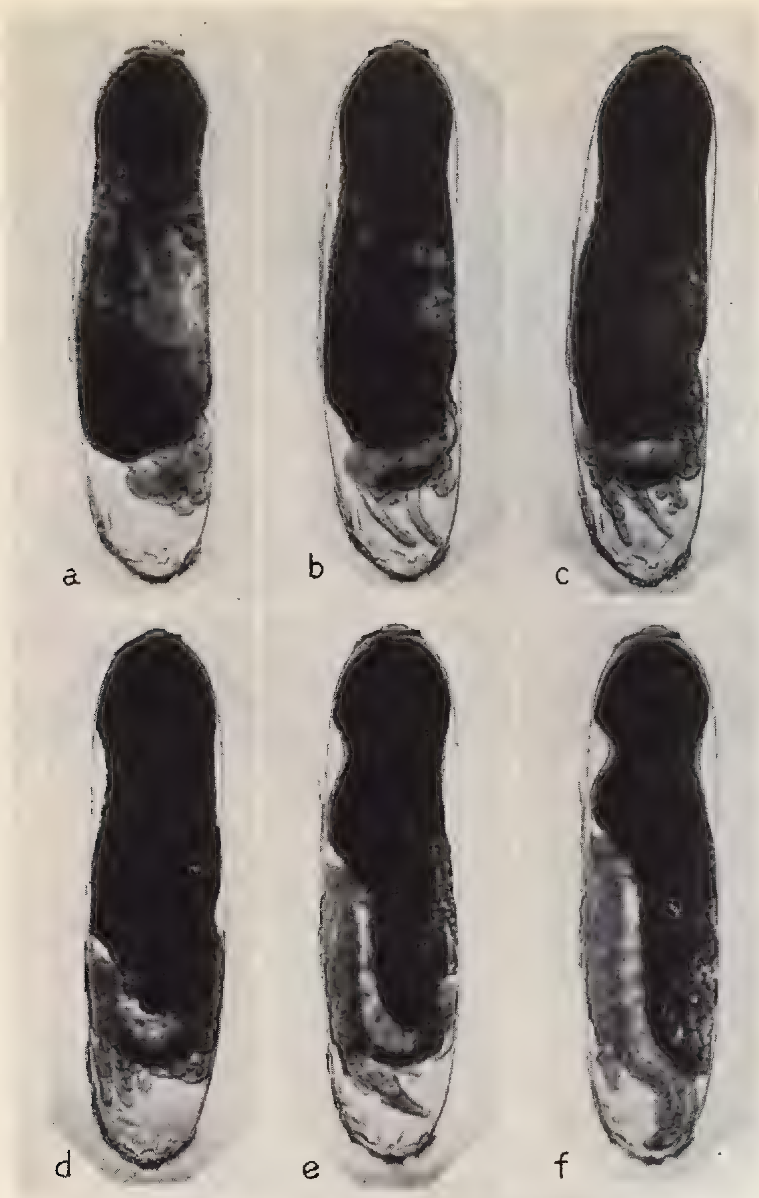
Anterior portion of the egg of *G. commodus* showing the final stage in engulfment of yolk and contraction of the serosa. A.P., anterior pole; ec, embryonic cuticle; se, serosa; sh, shell; y, yolk.

Contraction of the Serosa

The serosa, which lines the shell and encloses the yolk gradually contracts from the posterior pole as the yolk presumably becomes assimilated by the growing embryo (fig. 1, K-M). By the time the embryo is ready to revolve the serosa has contracted by about one-sixth of the length of the egg. After rupture of the amnio-serosa in front of the labrum the serosa remains attached to the amnion at the top of the protocephalic lobes (cephalic amnion, fig. 2). The serosa, now open at the posterior end, shrinks towards the anterior end of the egg. After revolution, the open rim of the serosa adheres to the embryo ventrally by means of cephalic amnion and dorsally by the remainder of the everted amnion, which temporarily forms a dorsal closure. Here the serosa thickens and makes a horizontal constriction about the yolk (fig. 1, O and fig. 3, stage 14). As the head of the embryo approaches the anterior pole the serosa becomes thickened and reduced in area until it forms a cap-like structure over the un-enclosed yolk at the head of the embryo. In a stained preparation the nuclei of the serosal cells are seen tightly packed together as the last of the yolk is being enclosed in the mid-gut (fig. 4). Finally the serosa is withdrawn into the head at the junction of the coronal and occipital sutures.

ACKNOWLEDGMENTS

The author gratefully acknowledges her indebtedness to Dr. T. O. Browning for his guidance, advice and criticism throughout the work. Mr. K. P. Phillips made the photographs in text figures and plates.



The embryo in a living egg of *Gryllulus commodus* photographed at various intervals during revolution.

Fig. a The protocephalic lobes and labrum emerging from the yolk and projecting freely into the fluid at the posterior end of the egg.

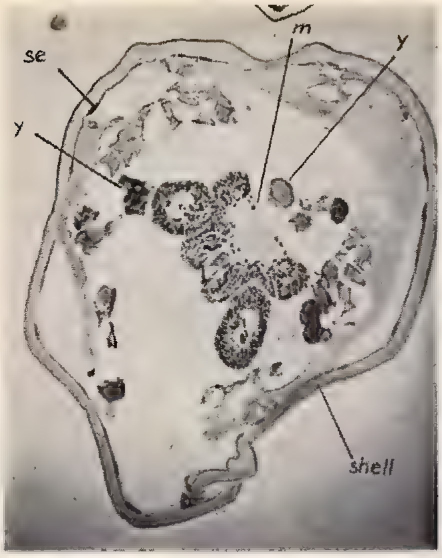
Fig. b After 20 minutes at about 18° C. the antennae hang freely in the fluid. The egg has accidentally rolled slightly so that the mouthparts are seen ventrally.

Fig. c After 50 minutes the maxillary palps have emerged from the yolk, followed by the labial palps.

Fig. d After 75 minutes the mouthparts are free and the first pair of legs are emerging from the yolk.

Fig. e After 170 minutes the head has reached half-way up the ventral side of the egg; the mouthparts, legs and pleuropodia are free; the remainder of the abdomen is being withdrawn from the yolk.

Fig. f After 280 minutes the embryo is in the final stages of revolution. The abdomen is beginning to straighten out as the head moves towards the anterior pole. The everted amnion encloses portion of the yolk dorsally.



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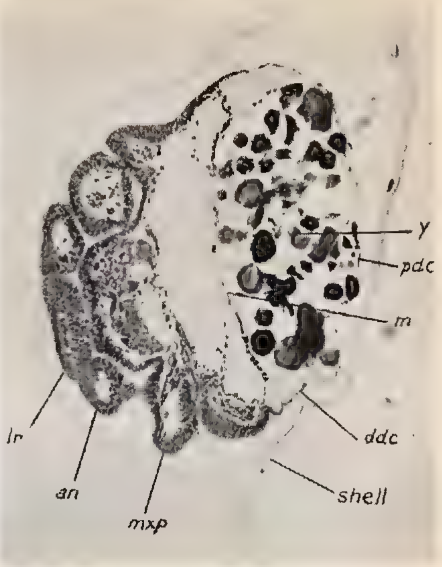

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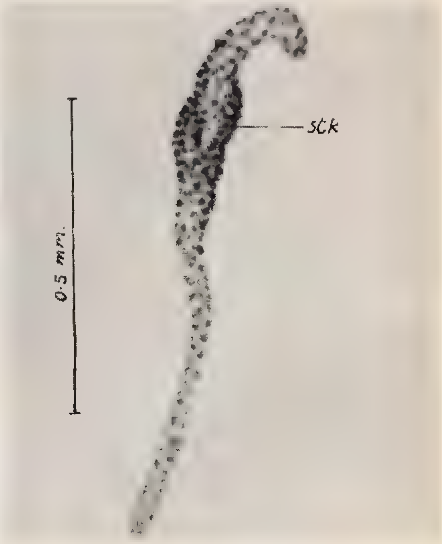

d

Provisional dorsal closure and pleuropodia in *Gryllulus commodus.*

Fig. a Transverse section of an egg (stage 11) through the embryo in the region of the first leg, showing the inner side of the embryo separated from the yolk dorsally by a membrance. X110.

Fig. b Transverse section of an egg (stage 14) through the embryo in the region of the labrum and maxillary palps. The yolk is enclosed in the incipient mid-gut, which is bounded dorsally by the amnion, forming a provisional dorsal closure. X110.

Fig. c Transverse section of an egg (stage 14) through the embryo to show the way the pleuropodia arise. Note the slender stalk and the large, widely-spaced nuclei in the wall of the pleuropodium. X110.

Fig. d A fully-developed pleuropodium adhering to the transparent shell of an egg incubated for 12½ days, showing the point of attachment of the stalk.

an, antenna; ddc, definitive dorsal closure; lr, labrum; m, membrane covering the dorsal side of the embryo; mxp, maxillary palp; pdc, provisional dorsal closure; pl, pleuropodium; se, serosa; stk, stalk of pleuropodium; y, yolk.

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PRECAMBRIAN TILLITES OF THE EVERARD RANGES, NORTH-WESTERN SOUTH AUSTRALIA

BY ALLAN F. WILSON

Summary

An unmetamorphosed Late Proterozoic succession begins with the Moorilyanna conglomerate. This fluvioglacial formation may be correlated with Ayers Rock and Mt. Olga on the northern flank of the Musgrave-Warburton Block, and the Sturt tillite near Adelaide. The reddish Chambers Bluff tillite occurs several thousands of feet above these basal beds, and may be correlated with the Elatina tillite in the Flinders Ranges. As the Mt. Chandler quartites are sub-horizontal, and overlie unconformably the Chambers Bluff tillite, they are not Nullagine, but most likely Ordovician.

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[Read 8 November 1951]

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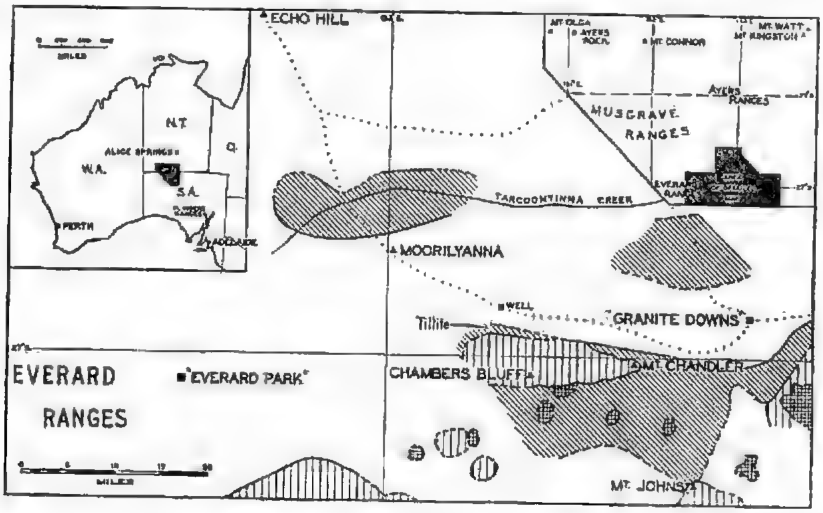

Fig. 1

Sketch map to illustrate approximate distribution east of the Everard Ranges of (?) Upper Cretaceous (crossed ruling), (?) Ordovician (vertical ruling), Proterozoic (oblique ruling), and Archaeozoic Systems (unruled, but also includes some sandplain).

INTRODUCTION

Lockhart Jack in 1915 was the first to recognise a tillite near the Everard Ranges, Central Australia. He correlated it with the Sturt tillite near Adelaide, and as such this would be the most northerly occurrence of Precambrian tillite known in Australia. (At the time of his report the Sturt tillite was considered to be Lower Cambrian in age.)

It was to investigate his tillite claim that a hurried trip was made to the locality in February 1949 while the author was on field work elsewhere in Central Australia. From what was seen in the time available, Lockhart Jack's interpretation of the area is valid, but another important tillite was discovered.

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THE PROTEROZOIC SUCCESSION

East of the Everard Ranges the Adelaide System (Proterozoic) occurs as two major blocks preserved by downthrows into the Archaean rocks. One of these blocks of sediments lies a little to the north of Moorilyanna Hill. The sedimentary succession has already been shown in Lockhart Jack's sketch section (1915, section facing p. 46). The most significant features are as follow.

North-east of Moorilyanna Hill he reported that these beds lie unconformably upon the Precambrian gneisses. The sediments are cut by large quartz veins, but by neither pegmatite nor dolerite dykes which are plentiful in the gneissic complex. The basal beds consist of conglomerate containing pebbles and boulders of an unusually large variety of rocks. They dip south off the gneisses at 30° to 35°, and this dip is maintained to the fault contact with the gneissic complex about five miles south. The conglomerate (for which the name *"Moorilyanna conglomerate"* is proposed) has interbedded arkose, fluvioglacial and slate members which make the formation between 2,500 and 3,000 feet thick. The matrix of some of these boulder beds is much more shaly than is normal for a conglomerate, and thin-section study leaves little doubt that much of this basal formation is of glacial origin.

This formation is followed by about 4,000 feet of light-grey slaty sediments with several prominent bands of quartite and conglomerate. Some of these seem to be of fluvioglacial origin. Then appears about 1,000 feet of dark-grey shaly material with interbedded pebble-bearing strata. As first recorded by Lockhart Jack, this is similar to certain facies of the famous Sturt tillite. The six or seven thousand feet of sediments stratigraphically beneath this material represent outwash from a nearby ice-capped mountainous terrain, but this particular 1,000-feet section of the succession is best explained as a deposit conditioned in the main by melting of icebergs. Numerous well-facetted erratics up to 18 inches across were found, but none as yet with definite glacial striae.

The succession continues through another two or three thousand feet of slates and conglomerates, but is terminated abruptly at an epidotized fault-contact with the Archaean gneissic complex.

The other (and larger) block of the Adelaide System lies to the south of Chambers Bluff, Mt. Chandler and Indulkana Creek, and may be traced southward for several miles to Mt. Johns where it is covered by (?) Ordovician sandstones. This area is made up primarily of slates, with lesser quantities of quartzite, grit, dolomite and tillite. These sediments are cut by quartz veins, but by neither the pegmatite nor dolerite dykes which are so plentiful in the nearby Archaean gneissic complex. Lockhart Jack shows a fault-contact with this complex.

The writer made a rapid reconnaissance south from the well 13 miles E.S.E. of Moorilyanna Hill. The contorted gneisses make a (concealed) fault-contact with slightly folded unmetamorphosed dolomitic shales 1¾ miles south of the well, i.e., 6 miles N.N.W. of Chambers Bluff. At this particular place nearly two thousand feet of dolomitic shales and occasional pale-fawn dolomites were encountered, most of which dip south about 30° to 40°. Then followed a white dense feldspathic quartzite which is about 200 feet thick. No unconformity seems to exist between the quartzite and the underlying shales. Above this quartzite was discovered a tillite, for which the name *"Chambers Bluff tillite"* is proposed. A thickness of about 300 feet is exposed before the series is unconformably covered by the sub-horizontal (?) Ordo-

vician quartzites. A prominent slaty cleavage (E-W, dip N. 45°) could easily be confused with bedding in this virtually non-stratified tillite. It is otherwise unmetamorphosed.

The Chambers Bluff tillite consists of a non-sorted rock-flour matrix with numerous erratics (up to three feet in diameter) of quartzites, granites, gneisses, limestone and various plutonic and volcanic rocks. Many are facetted, and several excellent examples of striated erratics were collected *in situ*.

The most impressive feature of the tillite is its unusual colour. The bottom half of the exposed tillite is fawn in colour, but the formation grades upward into a pinkish-brown facies, and finally into about 30 feet of dark purplish-red tillite. The colours appear to be neither a surface effect nor related to the nearby unconformity with the (?) Ordovician. Microslides indicate that some of the red members of this tillite contain up to 50% haematite, although they mostly contain only about 10%. The iron seems to be part of the original sediment and not a replacement feature. The source of the iron is unknown.

In colour the Chambers Bluff tillite is similar to the Elatina tillite which was recently described by Mawson (1949). This occurs about 9,000 feet stratigraphically above the (grey) Sturt tillite in the Adelaide System of the Flinders Ranges. However, tuffaceous material, which is characteristic of the Elatina tillite in the type locality, was not noticed in this new tillite, although the considerable number of remarkably fresh basic volcanic erratics may be significant in this respect.

The Chambers Bluff tillite appears to be several thousands of feet stratigraphically above the grey glacial and fluvioglacial sediments associated with the Moorilyanna conglomerate, which are probably of Sturtian age.

CORRELATIONS

The Moorilyanna conglomerates and associated fluvioglacials resemble the great boulder beds and arkoses of Mt. Olga and Ayers Rock on the northern flank of the Musgrave Ranges. As recorded by Ellis (1937, p. 24), Blatchford was the first to recognise the probable importance of ice action in the deposition of the Mt. Olga boulder beds. Many facetted boulders (but none with definite glacial striae) were seen, and the matrix of many parts of the Mt. Olga conglomerates is suggestive of tillite. In the writer's opinion, however, the bedded character of the deposit shows that, like the Moorilyanna beds, these are largely the result of outwash from the nearby mountainous ice-capped terrain. In addition, there may have been a little detritus from floating icebergs. Thus the basal beds of the Adelaide System in this region of Central Australia may be co-eval with the Sturtian (glacial) Series as developed in the Flinders and Mt. Lofty Ranges.

Mawson (1947, p. 275) has shown that most of the non-fossiliferous sub-horizontal quartzites and grits of Eyre Peninsula and west of Lake Torrens are probably basal beds of the Adelaide System and not Ordovician or Cambrian, as Lockhart Jack (1927) and Segnit (1939) and others have suggested. On this basis, however, some prefer to consider that the similar quartzites of the Mt. Chandler Range are, likewise, basal beds of the Adelaide System. This cannot be so, for the Mt. Chandler quartzites unconformably overlie the Chambers Bluff tillite. The Mt. Chandler quartzites are in turn overlain with slight unconformity by Upper Cretaceous Sandstones.

The Mt. Chandler quartzites are, therefore, post-Adelaide System but pre-Upper Cretaceous. H. Y. L. Brown (1905) and Lockhart Jack (1915,

p. 23) correlated them with the lithologically similar beds across the Northern Territory border at Mt. Kingston and Mt. Watt where Ordovician fossils have been found. At the new tillite locality a hurried examination of the grits and sandstones just above the unconformity showed abundant worm tracks and unusual circular impressions as well as gall-like nodules and typical clay-pellet impressions, an assemblage which is remarkably similar to that in undoubted Ordovician Sandstones some 120 miles to the north. Owing to lack of better evidence, the Mt. Chandler quartzites, which unconformably overlie the Chambers Bluff tillite, could continue to be considered of Ordovician age.

ACKNOWLEDGMENTS

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SEDIMENTS OF THE ADELAIDE SYSTEM IN THE MOUNT PLANTAGENET AREA, SOUTH AUSTRALIA

BY ALAN H. SPRY

Summary

In the Mount Plantagenet area, about 20 miles east of Hawker and 240 miles north of Adelaide, sediments of the Adelaide System are broadly folded into the Worumba Anticline and the Holowolina Syncline. The geology of the Hundred of Adams, Warcowie, Basedow and Wonoka and the country to the east is discussed. An upfaulted block of sediment from lower in the System has been introduced into the centre of the Anticline, replacing the western limb. The sediments of this block are rather sharply folded and crushed with the intrusion of about sixty small dolerite bodies. The nature of the sediments and estimate of the thickness of the formations represented is given. It is suggested that sediments of the Adelaide system of this area were laid down in very shallow water in miogeosyncline.

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In the Mount Plantagenet area, about 20 miles east of Hawker and 240 miles north of Adelaide, sediments of the Adelaide System are broadly folded into the Worumba Anticline and the Holowolina Syncline. The geology of the Hundred of Adams, Warcowie, Basedow and Wonoka and the country to the east is discussed. An upfaulted block of sediment from lower in the System has been introduced into the centre of the Anticline, replacing the western limb. The sediments of this block are rather sharply folded and crushed with the intrusion of about sixty small dolerite bodies. The nature of the sediments and an estimate of the thickness of the formations represented is given. It is suggested that sediments of the Adelaide system of this area were laid down in very shallow water in a miogeosyncline.

CONTENTS

INTRODUCTION

Owing to its comparative inaccessibility, only little previous geological work has been undertaken in this area. Segnit (1929) published geological notes on portion of the Hundred of Adams. Winton (1922) briefly mentioned some dolomites in a discussion of the guano deposits of the Arcoota and Good Friday caves. Professor Mawson made reconnaissances into portions of this area in

* This work was undertaken during 1950, aided by a Commonwealth Research Grant. The author wishes to thank Professors D. Mawson and E. A. Rudd for encouragement and assistance; also Dr. D. R. Bowes, B. Jennings and J. Spry for assistance in the field. Assistance was received also from R. C. Sprigg and A. Nie of the Geological Survey of South Australia. Best thanks must go to Brian Dearlove of Worumba Station for his most generous hospitality during my stay in that area.

connection with his investigation of the geology of the Warcowie region and the Bibliando Dome. David (1950), following Segnit, indicated that certain of the rocks (a fault-block) are Earlier Precambrian, but we disagree.

Scope of the Present Investigation

Only a small portion of the area is covered by detailed survey sheets and even these are so inaccurate as to be useless for mapping. Consequently the map was prepared from trimetrogon aerial photographs. Three vertical runs and the enclosed oblique photographs were plotted by radial line methods. The accuracy of this map is strictly limited both by the complete lack of reliable ground control and the inherent faults due to the use of oblique photographs.

Time limitations and lack of facilities prevented complete detailed mapping and attention had to be directed only to the broader regional features.

The primary object of the research assignment for thesis was an investigation of the igneous intrusives. These, however, are involved in a fault block and for the better comprehension of the latter a fuller examination of the surrounding sediments was deemed necessary. The structure and intrusives of the fault-block are discussed in a separate paper.

Economic Aspects

Apart from copper mineralization about the basic intrusions which is discussed elsewhere, there is little of economic interest in this area. Barytes occurs in scattered places along the great north-south fault and small quantities were found west of Worumba and at Morgan Well. The sedimentary magnesite which outcrops to the north-west of Yednalue and west of Mount Plantagenet does not show promise of economic exploitation. At Yednalue the thickest bed is fifteen feet and there is a total of less than eighty feet distributed through almost two thousand feet of sediment. The deposits near Mount Plantagenet are most difficult to reach and the remoteness of both occurrences would in any case limit their economic use.

Guano was found in several caves located in or near the Brighton Limestone horizon to the south of Holowolina, but this deposit was removed long ago.

REGIONAL STRUCTURE

Throughout the whole of the Flinders Ranges the Adelaide System has been thrown into a series of broad folds. The folding of the Upper Proterozoic sediments took place during Lower Palaeozoic time, perhaps as early as Upper Cambrian. The trends of the fold axes are approximately east-west on Kangaroo Island, then turn north-south on the Fleurieu Peninsula. The north-south trends continue almost to Hawker where the outcropping of the Adelaide System splits. One arm continues to the north while the other turns to the east to Broken Hill. In this central zone, domes and basins are common (at Cradock, Bibliando, Wilpena, Oraparinna, Enorama, Blinman, etc.), and in the area under consideration large folds with curved axes occur. The Bibliando Dome warp appears again to the west by a pitch reversal of the east-west anticlinal axis and forms an anticline plunging to the east. The direction of the axis continues to be east-west until about sixteen miles from the Dome where it swings sharply to the south. The majority of the western limb of this anticline has been removed by faulting but the eastern limb continues for about thirty miles to the south. This fold will be referred to as the Worumba Anticline. There is a large drag structure on the northern limb where the axial direction changes and a secondary fold over a mile across is outlined by the interglacial quartzite which is extensively broken by small faults. To the north and west of this fold, the sediments are overturned and dip steeply to the south across the plains to the Druid Range

Towards the south-east the beds are folded in a great synclinal trough. At the northern part the axis trends east-west and the plunge is to the west. The axis then swings to the south and the fold continues for about thirty miles without plunge until the trough closes with a pitch to the north. This fold will be referred to as the Holowolina Syncline.

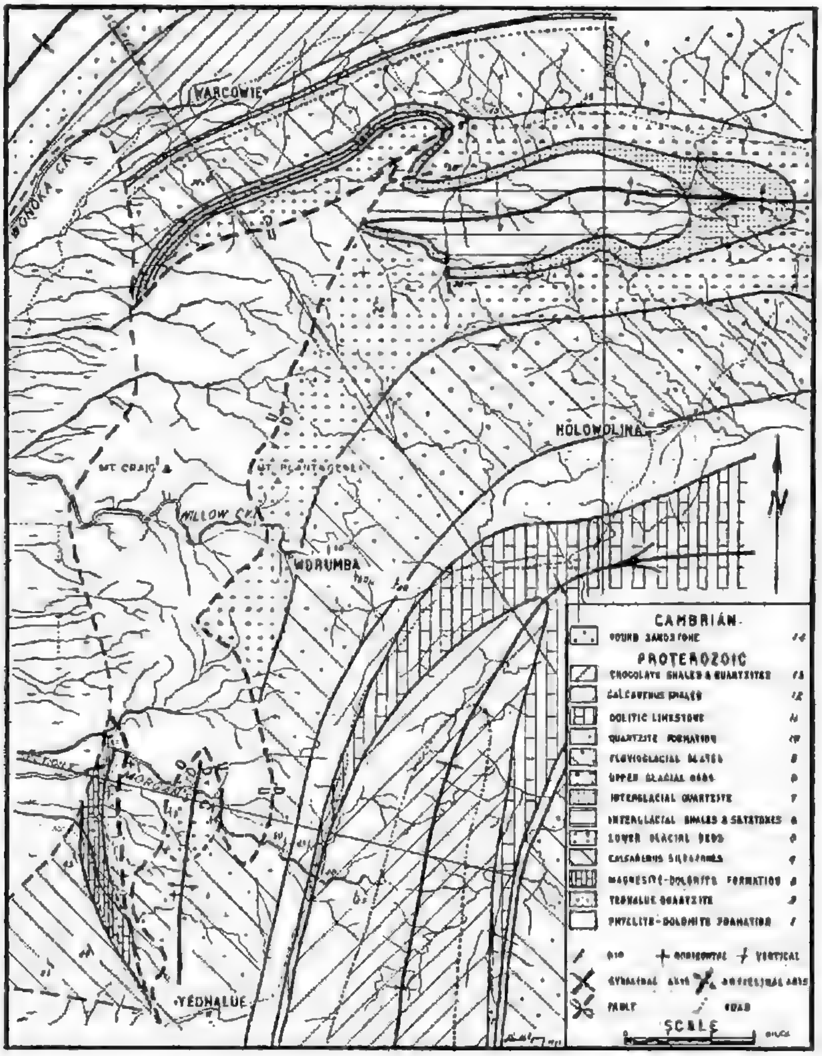

Fig. 1
A geological map showing the regional features of the Worumba-Holowolina area.

The folding within the fault block is on a smaller scale with folds similar to the large structures and with generally north-south axes. The abundant incompetent dolomites and phyllites in this block are contorted while the quartzites are frequently shattered.

In addition to the small faults and crush zones which are obvious in the field, there are three major faults with considerable displacements. The phyllite-dolomite formation is bounded on all sides by these faults, and has moved up as a great block cutting off portion of the western limb of the Worumba Anticline.

The great north-south fault which passes to the west of Worumba is very tenuous in outline. This fault is accompanied by considerable shearing and brecciation and has a stratigraphic displacement of about nine thousand feet in the north and about fourteen thousand feet in the south. Segnit (1929) recorded this as an unconformity, but apart from the brecciation in the fault zone, the fault transgresses over five thousand feet of sediments in twenty miles. The phyllite-dolomite formation is in contact with the lower glacial beds, the upper glacial beds and the fluvioglacial slates and the relation is not one of unconformity. Just north of Morgan Creek there is a cross fault which causes a tongue of the phyllite-dolomite formation to run into the upper glacial and fluvioglacial beds.

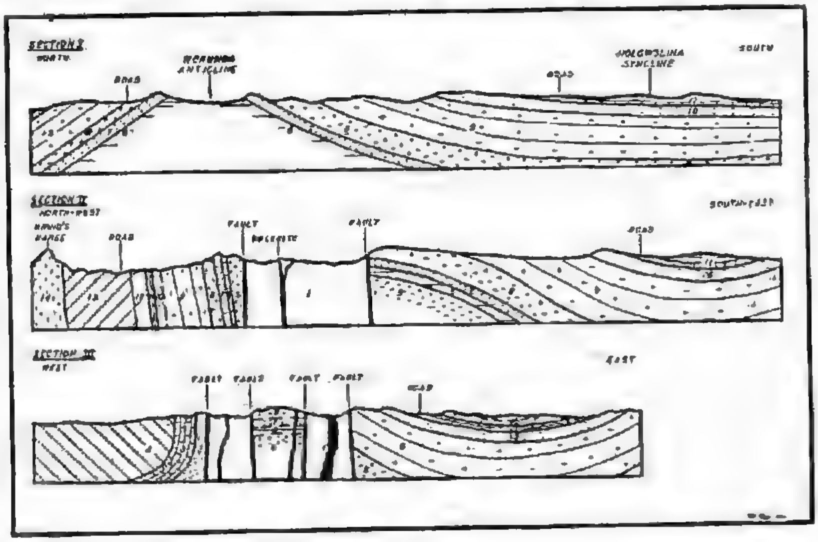

Fig. 2
Sketch sections across the map shown in fig. 1.

Another large fault occurs parallel to the north-west limb of the Anticline and meets the north-south fault near the drag structure previously mentioned. The stratigraphic throw of nine thousand feet of this fault is difficult to account for. Both the beds and the fault appear to be steeply dipping and any movement would be along the bedding planes and a large stratigraphic displacement would not occur. The tenuous outline of the faults and their large stratigraphic throw suggests that the faults may be low angle thrusts. The Anticline is quite asymmetric and overturned, and these features are frequently associated with thrusts. However, it was established in several places in the field that the attitude of the fault was approximately vertical. There was probably considerable horizontal movement along this fault. Another structural peculiarity occurs in the eastern part of the Anticline. Like many anticlines in the Flinders Ranges, the dips steepen towards the centre of the fold giving a "pinched" structure. However, the interglacial shales which are vertical in the centre appear to be a great deal thicker than their normal thousand feet. It is likely that there is some puckering in the axial zone, but outcrops were too poor to establish this in the time available.

The pattern of forces required to produce these structures is complex and indefinite. A strong thrust from the south-east would produce the fold system with curved axes and would also account for the overturning in the north-west. The secondary drag fold was next to form, due to shearing in a north-east direction. The faulting was probably associated with the last stage of this second folding and appears to have been due to vertical forces transmitted through the

basement. The theory of the strain ellipsoid was applied to the structures in an effort to explain the fold-fault system by a simple set of forces, but it was found that there was no simple explanation which would account for the combination of folds with curved axes and intersecting normal and partly transcurrent faults.

TOPOGRAPHY

The area is subject to moderate aridity. High temperature and low rainfall condition the processes of weathering. In its distribution the vegetation is mainly dependent on the underlying rock types. For instance, eucalypts flourish on magnesia-rich soils over the magnesite-dolomite formation, also on the interglacial shales, while stunted pines and spinifex are usually restricted to the high barren ridges composed of glacial and glaciofluvial beds.

There is a sudden change from the flat alluvial plain in the west to the rugged peaks of the interglacial quartzite ridge. The higher ground is controlled by the arcuate form of the Worumba Anticline and a series of ranges sweeps around from the south-west to the northeast. The area in the south-east is smoother, and low rounded hills occur in the region of the limestones and calcareous shales of the Holowolina Syncline.

The drainage system may be divided into two portions. The one shows a distinct relation to the geological structure while the other is characterised by a more obscure regional control. The rivers which drain the Worumba Anticline illustrates the first of these The anticline is normal in that it is well eroded in its axial zone. There is a slightly trellised river system with consequent, subsequent and obsequent streams.

Rivers of the second drainage type are typified by the Wonoka which flows along the base of the Druid Range across a wide alluvial plain. Willow Creek and Morgan Creek (together with a host of small unnamed watercourses) flow out of the hills across this plain to the west. It is of some interest that the Morgan shows a well-preserved truncated meander with the present course several feet below the old bed.

The topographic expression of the more prominent formations is summarized below.

The phyllite-dolomite formation—The folded phyllites, dolomites and quartzites within the fault-block show a variety of forms. The dolomites are surprisingly resistant and some ridges with a quartzite core are most rugged. The slates and phyllites weather to rolling grassy hills. The dolerite plugs are not particularly resistant but may form quite high conical hills as at the "Three Sisters" about six miles north-west of Worumba.

The Yednalue quartzite—This horizon is more notable in a physiographic than a stratigraphic sense and it forms the range of rounded hills to the east of the road which leads north-west from Yednalue.

The magnesite-dolomite formation is easily eroded and rarely forms obtrusive hills. It supports a stunted eucalypt flora. This feature is very noticeable just north-west of Yednalue where a narrow belt of trees is visible in the aerial photographs.

The glacial beds—The tough conglomerates, quartzite and siltstones form a series of high rugged hills. Mount Plantagenet (pl. x, fig. 3) is the highest point in the area and is composed of the upper glacial beds.

The quartzite formation—The massive siliceous members of this formation stand up as a well-defined range from Yednalue to Holowolina.

The immensely thick Pound Sandstone formation, regarded by Mawson as probably constituting the base of the Cambrian sequence, extends as the Druid Range in sky-line relief along the northern limit of the area under consideration.

PROTEROZOIC FORMATIONS OF THE ADELAIDE SYSTEM

During field investigation the Proterozoic rocks were sub-divided into formations according to their lithological characteristics and a local name was given to each. Correlation with the sequence in the vicinity of Adelaide (Mawson and Sprigg 1950) is possible by means of the main marker horizons, and the formations may be renamed with some certainty of a correct relation to the type sequence. The nomenclature conforms as closely as possible with the *stratigraphic code* (Raggatt 1950). In the following discussion of the nature and the possible environment of deposition of the beds of the Adelaide System in this area, the local field name and the probable equivalent in the type section are given.

A series of stratigraphic columns shown in fig. 3 illustrates the correlation in various areas in the Mount Lofty-Flinders Ranges and shows the correctness of Mawson's (1947) contention, namely, the distinct thickening towards the centre of the geosyncline (at Hawker and Bibliando), with thinning most marked towards the edges (particularly Copley). An attempt is made to determine the tectonic environment during the various phases of deposition.

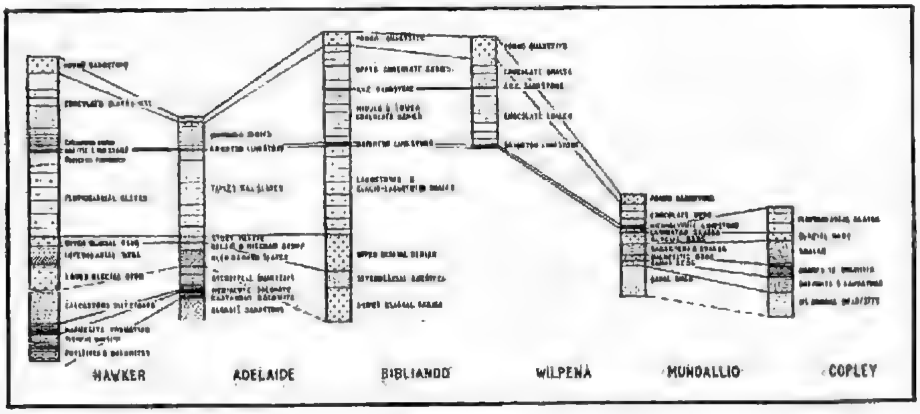

Fig. 3

Stratigraphic columns showing the correlation between the Hawker area and the type section at Adelaide. Additional columns show the general thickening to the north and to the centre of the geosyncline and thinning towards the western edge.

The phyllite-dolomite formation

This formation consists of more than two thousand two hundred feet of dolomite, phyllite and quartzite and is probably the equivalent in the Adelaide area of the Castambul Dolomite together with the slates, phyllites and quartzites immediately above and below it it. The similarity to the "argillites and dolomites" near Mount Painter which Mawson (1948 b) called the Arkaroola Series is striking. These beds underlie a massive quartzite which Mawson correlated with the Emeroo Quartzite as the base of the Adelaide System and were regarded as an older series. The formation is richly dolomitic in part, and is also slightly metamorphosed and contains basalts "in part, at least, intrusive". If this correlation is correct then the thin Yednalue quartzite would be the equivalent of the massive arenite horizons at Emeroo Range, Mount Aroona, etc.

The formation is typified by the occurrence of great thicknesses of pure and argillaceous dolomites and dolomitic shales and phyllites. Some beds show cross-bedding and there is an indication in several localities that slumping and intraformational brecciation may have taken place. The formation is confined to a block whose limits are marked by faults. A low grade of regional metamorphism

prevails irregularly over this fault-block. There has been intrusion and possibly extrusion of basic magma at a period related to the early Palaeozoic folding.

Petrographically, the rocks are characterised by the presence of dolomite, angular quartz particles and fragments of fresh angular feldspar with secondary chlorite, biotite and talc. Apart from the abundance of carbonate, the phyllites resemble low-rank greywackes which have been mildly metamorphosed to the green-schist facies (Turner, 1948).

Phyllites which occur between Worumba and Mount Craig, are light-grey rocks with a poorly developed schistosity. They contain porphyroblasts of allothogenic quartz up to 2·5 mm. in diameter, with feldspar (angular to sub-rounded) set in a groundmass containing abundant fresh greenish-brown biotite and idioblastic dolomite and a little talc. Accessories are apatite, iron ore and tourmaline.

The dolomites vary in colour from deep blue-grey to yellow and are frequently rather fine-grained. Some recrystallization, however, usually increases the grain size in an irregular manner. There is a wide range of pure to argillaceous and arenaceous varieties. Specimen [S 16] is a fine-grained dolomite from Morgan Well. It shows bands rich in angular quartz or feldspar through a granoblastic mass of dolomite. A little pyrites and rutile are present.

Specimen [9014] which occurs near the contact of the large dolerite intrusion north-east of Morgan Well is fine-grained, yellow, and exhibits occasional idioblastic dolomite crystals. It is porphyroblastic with large well-formed dolomite laths set in a groundmass consisting of rounded dolomite crystals in a fine mesh of talc. A little secondary quartz occurs in veins. The rock contains 52·2% of insoluble material which is chiefly talc, 22·0% of $CaCO_3$ and 25·0% of $MgCO_3$.

The quartzites are usually reddish-brown in colour with a very fine grain. They occur in beds from several inches to hundreds of feet in thickness.

The presence of dolomite in most of the rocks of this formation, together with the variable ratio of $CaCO_3$ to $MgCO_3$, suggests that the magnesian limestones may have been formed by a process of penecontemporaneous dolomitization. However, it will be shown later that the dolomite was probably precipitated under extreme chemical conditions. The beds probably formed in moderately shallow to deep water in a tectonically active area.

The Yednalue quartzite

This horizon has no definite equivalent elsewhere and is only notable for its topographic expression. In its thickness of 750 feet there is less than 500 feet of quartzite and most of this occurs in narrow bands with shale. The largest arenaceous bed is about 280 feet thick. The rock is a rather coarse-grained cross-bedded arenite which varies from a sandstone to a quartzite. The chief significance of this bed is that it marks a period of dominantly clastic deposition after the dolomites of the phyllite-dolomite formation and before the dolomites and magnesites above. It indicates a fairly shallow-water environment and moderately stable tectonic conditions.

The magnesite-dolomite formation

This horizon is remarkably persistent and has been noted in many places in the Flinders Ranges by Mawson (1941B, 1947), and was correlated with the Upper Torrens Dolomite, (now called the Montacute Dolomite, Mawson and Sprigg; 1950) by Sprigg (1946). The extreme conditions required for the deposition of sedimentary magnesite were probably not repeated during deposition of the Adelaide System, and consequently the magnesite horizon is probably the most reliable marker horizon for correlation purposes.

In a well-exposed section, three miles north-west of Yednalue station, this formation extends for about 2,300 feet. Of this thickness only 70 feet is magnesite, while there is about 1,300 feet of shale, almost 1,000 feet of dolomite and 20 feet of grit and sandstone. The magnesite is distributed through the lower 1,400 feet of the formation as beds of a foot or two in thickness, although a bed of impure pellet magnesite is 12 feet thick. The sequence shows a poorly developed cyclic form with a large number of thin dolomite, shale, magnesite and grit beds.

The shales are usually soft and grey in colour and weather more quickly than the other sediments. They contain an appreciable amount of carbonate.

The dolomites are usually a dark blue-grey and vary from massive, flaggy varieties to thinly-laminated shaley rocks. Some horizons contain abundant black rounded chert fragments. A compact dark-blue dolomite [S 66] is very fine-grained and contains 41·0% of $MgCO_3$, 55·6% $CaCO_3$ and 3% of insoluble material. The insoluble portion contains a little angular quartz and a considerable amount of fine, black carbonaceous matter. An arenaceous dolomite [9072] is a light-grey rock with abundant grains of glassy quartz set in a fine-grained dolomite matrix. It has a porphyroblastic texture shown by quartz and feldspar fragments together with ooliths in the finely crystalline dolomite base. The quartz varies in size up to 0·6 mm. in diameter and shows angular outlines due to well-developed secondary growth about originally rounded grains. The feldspar is fresh microcline showing cross-hatching. The ooliths are both round and ovoid up to 0·6 mm. in diameter. They are composed of dolomite with a crystalline centre and a dark fine-grained border. Finely divided talc and rutile occur in the crystalline matrix. Chemical analysis shows 39·0% $CaCO_3$, 30·1% $MgCO_3$ and 28·6% of insoluble material.

The arenaceous rocks vary from quartzites to gritty dolomites. A coarse buff-coloured quartzite [S 26] found one and a half miles west of Worumba, is sub-arkosic. It contains angular to sub-angular quartz grains varying in size from an average of 0·1 mm. to 0·6 mm. There is lesser albite and microcline present as moderately fresh grains. Tourmaline and limonite are accessories.

A dolomitic grit outcropping three miles north-west of Yednalue is a light-grey gritty rock. It consists chiefly of rounded to angular fragments of quartz with lesser fresh albite and microcline with a dolomite cement. Also present are a few ooliths and a rock fragment (graphic quartz-feldspar intergrowth) with a little talc and chlorite. Both the quartz and feldspar show the effects of secondary enlargement. The quartz tends towards fully-formed crystalline shapes, while the albite and microcline show a secondary peripheral zone with cleavages and twinning continuous across the whole crystal. The occurrence of authigenic microcline which shows the typical cross-hatching is rather unique.

A well-banded dolomitic siltstone [9073] from Willow Creek, about three-quarters of a mile west of Worumba also occurs in this formation. It is a dark-coloured strongly banded rock which is very fine in grain. A partial chemical analysis shows 68% quartz and 32% dolomite with only a slight amount of argillaceous material. The quartz is present as very small angular particles. The bedding is shown by bands rich in fine-grained dolomite, with poorly developed ripples and cross bedding visible.

The magnesitic beds occur to the north-west of Yednalue and again west of Worumba and Mount Plantagenet. In the latter area the sequence is indefinite and the relation to the nearby phyllite-dolomite formation is not clear. A bed of material resembling a pellet magnesite occurs on the south end of the ridge west of Mount Craig. The rock consists of a number of round buff-coloured pellets cemented by dark-blue dolomite. In one band the pellets are roughly spherical and about 5 mm. in diameter, while in the other the pellets are rather oval and

several cm. across. An analysis of a pellet gives 57% $MgCO_3$, 38% $CaCO_3$ and 3% of insoluble material. The pellets are often corroded about the edges, and some ooliths are present. This bed shows some lithological similarities to the pellet magnesite, but its field relations rather indicate that it is a member of the phyllite-dolomite formation.

The magnesite itself occurs in two distinct forms. There are beds entirely composed of white cryptocrystalline magnesite which is homogeneous and breaks with a conchoidal fracture. The beds which are referred to as pellet magnesites consist of rounded fragments of the cryptocrystalline variety, cemented by crystalline carbonate. The most common pellet rock is typified by [S 39] from the western flank of Mount Plantagenet. It is a pale bluish-grey rock, and an analysis shows 83·2% $MgCO_3$, 7·0% $CaCO_3$, 3·5% Fe_2O_3, Al_2O_3, etc., and 6·1% insoluble material. The magnesite pellets are rounded to angular in shape and vary in size up to 10 mm. in diameter. Under the microscope they appear as a brownish mass of exceedingly fine-grained material. Some authigenic talc is present, and this forms the bulk of the insoluble fraction.

A light-grey breccia [S 28] which occurs one mile west of Worumba on Willow Creek is a subarkosic pellet magnesite rock and is different from the common variety described above. It contains sub-angular to angular fragments of quartz and feldspar up to 2·0 mm. across, together with highly angular magnesite pellets up to 4 mm. long. The feldspar is very fresh and is occasionally poikiloblastically associated with dolomite, suggesting that the feldspar may be authigenic. The quartz shows the effects of secondary peripheral growth, and a little talc is present.

The pellet magnesite is seen to be directly derived from the cryptocrystalline beds by a process of penecontemporaneous erosion. This process is similar to one described by Howchin (1920) for the formation of mud-flake breccias and was recognised by Mawson (1947). The lower bands of white are broken up (possibly by subaerial drying) and the flakes incorporated in the bed above.

The origin of the white cryptocrystalline magnesite, however, presents a difficult problem.

A certain amount is known, or may be deduced concerning the environment of deposition of the magnesite, and this in turn forms a basis for suggestions for a mechanism of deposition. The formation contains examples of ripple marks, cross bedding and sun cracks, while some magnesite beds contain ooliths. The pellet magnesites were formed by erosion and redeposition of the massive magnesite. These facts indicate that deposition took place in an environment that varied between mud flats and very shallow water. The presence of pure dolomites and magnesites with alternations of shales, indicates that tectonic conditions were stable. The gritty bands are in the minority and indicate brief periods of tectonic activity. The presence of angular quartz and fresh feldspar, and a fragment of quartz-feldspar rock in the sediments points to an igneous or metamorphic terrain for the source of the clastic material. The magnesite is found over a large area in the Flinders Ranges, and thus it seems likely that deposition took place in a large, calm, shallow basin. From the peculiarity of the type of sedimentation, it does not seem likely that this basin was capable of free circulation with the open ocean.

When Mawson (1941a) established the existence of bedded magnesite horizons as part of the Adelaide System, he first suggested that the outcrops might be explained as due to surface secondary enrichment in magnesium of original dolomite, with the expectation that the high magnesia value would fade at depth.

However, the above speculation ceased when mining operations commenced. The continuity in depth of the magnesite was then proved, also the pellet struc-

ture exhibited by some of the magnesite beds demonstrated a primary sedimentary origin.

In searching for an explanation to account for this notable precipitation of magnesite, despite the apparent lack of organic remains in the Proterozoic rocks of the Adelaide System, consideration may be given to the possibility that it was effected by primitive algae. Long ago in Upper Proterozoic limestones of the Adelaide System in South and Central Australia there was found (Mawson 1925 and Mawson and Madigan 1930) structures whose origin was referred to the activities of algae. Twenhofel (1939) mentions that some algae may secrete up to 25% of magnesium carbonate. However, from the complete lack of organic remains in this formation, and the lack of knowledge of an organism which could precipitate 100% magnesium carbonate, it seems likely that a theory of organic precipitation is untenable.

If now we consider that the magnesium carbonate was precipitated from solution as such, then this may have been due to evaporation or to chemical reaction. The extreme fineness of grain of the magnesite and the lack of associated salt deposits or salt paramorphs in associated argillaceous beds tends to contradict an evaporite origin.

Thus it seems most likely that the magnesium carbonate was precipitated by a chemical reaction under abnormal conditions.

On account of the small concentration of magnesium in sea water and the greater solubility of magnesium carbonate as compared with calcium carbonate, it is obvious that the possibility of direct precipitation of magnesite from sea water as we know it today, even under the most abnormal physical chemical environment, must be very small indeed.

Even allowing for considerable differences in the saline content of the waters of Precambrian seas, as suggested by Daly (1909), it is not obvious how there could be precipitated such large scale deposition of magnesite as is embodied in the Adelaide Series.

Bain (1934) suggested that sedimentary magnesite might be due to the precipitation of hydro-magnesite, which is relatively insoluble. This apparently would change to magnesite under the influence of carbon dioxide in solution, over a period of time. To explain the origin of certain American sedimentary magnesites he postulated a basin containing brine rich in sodium carbonate into which flowed a solution containing abundant magnesium salts.

Bateman (1942) mentions the occurrence of 200 feet of sedimentary magnesia in Nevada, and other deposits in Kern County, California, Idaho, British Columbia and Germany. These are apparently local deposits associated with salt, gypsum, shales and limestone. He adopts Bain's mechanism of deposition.

It is possible that Bain's explanation or some modification of it may account for the magnesites of the Adelaide System. They were deposited in an extensive geosynclinal basin but on a scale far exceeding that considered by Bain. To reproduce the conditions postulated by Bain contemporaneous vulcanism is required. So far the existence of such is known on a limited scale only. However, it may be that an area of more intense volcanic activity existed to the east of the basin.

To summarize, it is considered that the magnesite was precipitated from solution as hydromagnesite by chemical reactions. The process took place in a large shallow basin, under possibly arid conditions. It would appear probable that intense volcanic activity contributed waters rich in sodium carbonate which reacted with magnesium salts in solution to produce insoluble hydro-magnesite.

The Calcareous Siltstones

This group occurs only to the north-west and west of Yednalue. It is stratigraphically above the magnesite-dolomite formation but does not extend up as far as the lower glacial beds in this area. The rocks outcrop over a series of low hills and dip at increasingly shallow angles to the west towards the alluvial plains, bordering the road from Cradock to Hawker. These are a series of blue calcareous siltstones, quartzites and a little limestone. The beds show cross bedding and intraformational slumping.

Rock [9070] is fairly typical of these calcareous siltstones. It is a light-grey fine-grained rock showing cross-bedding etched in relief by weathering. It contains angular quartz particles up to 0·15 mm. across set in a fine-grained matrix rich in calcite and indefinite micas. There are a few flakes of recognisable sericite and biotite.

Rock [9068] approaches the sub-greywacke facies more closely than any other rock in this area. It is fine-grained and greenish with a dense homogeneous texture, and consists of subangular quartz and lesser microcline set in an indefinite micaceous groundmass. The texture is irregular with large areas of the matrix free from the large clastic particles. A partial analysis yielded 24·9% $CaCO_3$, 1% $MgCO_3$ and 74% of insoluble material. The matrix is difficult to resolve but consists mostly of green chlorite with abundant calcite and limonite and with accessory tourmaline, iron-ore and zircon.

The tendency towards poorly washed and sorted sediments becomes more notable in this division, and the approach in lithological character to the greywacke facies probably indicates tectonic instability as a prelude to glaciation.

The Lower Glacial Beds

The lower glacial horizon is equivalent to the Bibliando glacigene beds to the east (Mawson 1949), and these have been tentatively correlated with the arkoses and varve-like shales of the Mitcham Quartzite.

In this area, the beds occur only on the western overturned portion on the northern flank of the Worumba Anticline. Here the formation extends for about 3,870 feet and contains gritty tillite and boulder beds together with abundant shales and siltstones. There are numerous erratics in the tillite of dolomite, quartzite and shale which are lithologically identical with beds lower in the Adelaide System. This feature has been noticed frequently and Mawson (1948) has stated that there was terrestrial glaciation with erosion of the previously deposited sediments. In this particular series of glacial beds there is comparatively little true unsorted boulder tillite and the beds are chiefly fluvioglacial in origin. There is a little limestone interbedded near the base. The thickness of 3,870 feet given for this formation is not the actual maximum as the lower part of the sequence has been removed by faulting. Thus there is a period between the lower glacial beds and the underlying calcareous siltstone of which there is no record in this area.

Interglacial Beds

The formation which separates the upper and lower glacial horizons is correlated directly with Mawson's (1948) Willyerpa quartzite and the accompanying shales at the Bibliando Dome. They would appear to be contemporaneous with the Mitcham quartzites at Adelaide. Almost 900 feet of quartzite and 230 feet of shales and siltstones at the western part of the Worumba Anticline are compared with the 1,200 feet arkose and quartzite and the 850 feet of arenites with some minor silty and shaley bands at Bibliando.

The quartzite forms a massive rugged range which outlines the form of the Worumba Anticline in bold topographic relief. A specimen [9075] is a light reddish-brown quartzite with a hard massive appearance. A little decayed feldspar appears as spots of kaolin but there is not sufficient feldspar present to suggest an arkose similar to those which occur in this horizon at the Bibliando Dome. It is a medium-grained granulose rock consisting almost entirely of quartz in well-rounded grains up to 0·4 mm. in diameter. A few grains of quartz are subangular and there is a little chert present. Secondary peripheral crystallization is frequent, and the rock has a strong siliceous cement. It is of interest to note that the suite of accessory minerals (tourmaline, apatite, zircon, rutile, muscovite, and iron ore) is typical of this horizon in the Bibliando Dome, about 25 miles to the east.

This rock is an orthoquartzite typical of a tectonically stable shelf in a normal climate rather than a geosynclinal deposit with glacial associations.

The Upper Glacial Beds

This series of glacigene rocks is most irregular in its developments, even though it is equivalent to the Sturt tillite at Adelaide, and consequently is a widespread persistent horizon throughout the Flinders Ranges. In the northern parts of the Bibliando Dome, Mawson (1948a) has shown it to be 4,550 feet thick and containing almost 400 feet of true tillite with grits, shales, siltstones and sandstones. At 25 miles west on the northern part of the Worumba Anticline it is scarcely recognisable and consists of almost 1,000 feet of blue-grey gritty quartzite with bands of angular gritty tillite. On the western flank of Mount Plantagenet, it is well developed with three distinct boulder-tillite horizons. There are erratics of quartzite, limestone, pegmatite, sillimanite schist, granite and slate. In the lowest part of the sequence there are tillites with matrices containing up to 50% $CaCO_3$.

A specimen of tillite [9106] from this locality has a fine-grained base. In one thin section there are four pieces of fine-grained basic igneous rocks, the largest being 3·9 mm. across. These consist chiefly of weathered plagioclase laths with calcite and micaceous material. The most abundant rock type present as fragments is a quartz-calcite-albite rock. This occurs as subangular particles up to 2·6 mm. x 1·2 mm. in size and composed of varying proportions of the three minerals. Also present are quartzites, a plagioclase-mica-quartz rock, a biotite-feldspar-quartz schist together with the minerals quartz, microcline and plagioclase. Authigenic minerals are calcite, talc, biotite, chlorite and muscovite. The finely divided groundmass is rich in indefinite micas and iron-ore.

A siltstone [S 31] from just above the lower tillite bed is a light-coloured rock, fine in grain and showing well developed cross-bedding. It contains abundant tiny angular quartz grains with a little albite in a matrix of green micas. Calcite is abundant and is concentrated in certain bands. Also present are minor amounts of sericite, iron ore and limonite.

The Fluvioglacial Beds

This formation extends from the upper limit of the upper glacial horizon almost to the limestone of the Brighton horizon and is correlated with the Tapley Hill Slates near Adelaide. The thickness and lithology is variable in different parts of this area. Along the Waiaca Creek, the sequence consists of 8,000 feet of blue-grey banded siltstones and slates, with shales and narrow cross-bedded quartzites. Small sandy lenses are common in the lower parts.

A siltstone [9066] from Waiaca Creek, is a dark-grey fine-grained rock with a fine banding. A prominent feature, particularly in the field, is a system of small calcite-filled gash veins. It consists chiefly of small angular quartz frag-

ments (0·1 mm. in diameter) with lesser feldspar in a fine matrix of indefinite micaceous material. There are bands richer in feldspar and chlorite. A small gash vein filled with calcite showing comb structure is prominent although the rock contains only 4% of $CaCO_3$ by analysis.

The Quartzite Formation

This formation outcrops as the line of hills to the west of the Yednalue-Holowolina road. Here it occurs as almost two thousand feet of buff to blue-grey quartzites and siltstones with a little grit, limestone, slate and sub-greywacke. It is one of the few horizons in the Adelaide System which shows rapid facies changes along the strike and south of Warcowie, on the other limb of the anticline, this formation is scarcely recognisable and is represented by a little over 300 feet of grey quartzite and grit.

A siltstone [9078] from the Holowolina road is a fine-grained grey rock showing no bedding, and breaking with a conchoidal fracture. It is even-grained and consists chiefly of angular quartz (averaging 0·1 mm. in diameter), together with abundant chlorite and a little biotite. Angular albite and microcline are present with accessory iron-ore, rutile, tourmaline, muscovite, apatite and zircon.

Some beds approach low-rank greywackes, and this formation may represent sedimentation during the dying phase of the tectonic activity during glaciation.

The Oolitic Limestone

This bed is equivalent to the Brighton limestone at Adelaide and is a useful and persistent marker horizon. It occurs as a buff oolitic limestone between 240 feet and 300 feet in thickness, and varies to grey, non-oolitic and arenaceous varieties. On analysis it was found to contain 98·2% of $CaCO_3$ and is thus the lowest non-magnesian limestone in the Adelaide System in this area.

A specimen [9063] from the Holowolina road is buff and oolitic with a slight banding. It consists of an aggregate of ooliths cemented by crystalline calcite, pl. xi, fig. 5. The ooliths are rounded or ovoid in shape and average 0·8 mm. x 0·6 mm. in size. Individuals have a dark-coloured finely crystalline centre, the whole being composed of calcite. Some ooliths contain a moderately large quartz fragment and some of this silica is authigenic. There is a well-defined preferred orientation shown by the long axes of the ooliths; Sprigg [1946] has attributed this elongation to flow during folding. Also present are minor amounts of quartz, microcline and talc. The quartz almost invariably shows the effect of secondary peripheral crystallization with the consequent obliteration of the original clastic shape. Some show the growth of prism and pyramid faces, while others are rounded with pitted surfaces.

This bed grades upwards into grey limestone and grey calcareous shales and some difficulty was experienced in mapping the extent south of Holowolina, where the dips are very flat on the nose of the syncline.

The nature of the limestone indicates deposition in very shallow water under stable tectonic conditions.

The Calcareous Shales

Just above the oolitic limestone there is a variable thickness of calcareous shale which forms the base of the chocolate shales. These beds cover a large area in the centre of the Holowolina syncline and appear to be 3,500 feet thick, whereas along the Waiaca Creek there is less than 1,200 feet. In the former area the sequence begins with 200 feet of grey limestone which merges into the oolitic limestone below and the grey calcareous shales above.

The apparent thickening of the zone between the oolitic limestone and the chocolate beds is probably due to the lack of the typical red colour of the lower part of the chocolate slate formation.

The Chocolate Slates

The upper part of the Marinoan Series of the Adelaide System is characterized by the presence of chocolate and purple slates and quartzites. Here almost 8,000 feet of steeply dipping (overturned) chocolate-coloured beds occur in a zone parallel to and south of the Druids Range (Mawson 1941b). The sequence is composed chiefly of slates, siliceous slates and shales, siltstones and grey quartzites with abundant thin grey limestones in the upper parts. Cross bedding, ripple marks, sun cracks and curious flowing markings (pl. xi, fig. 4) occur. At the very top there are several hundred feet of blue, buff and grey limestones showing intraformational slumping. There follows six hundred feet of red sandstone before the massive white Pound Sandstone of Cambrian age is met.

The depositional environment of the "red beds" of the Adelaide System is rather unique and has been investigated by a number of workers. The beds show the characteristics of shallow water deposition under moderately stable conditions. The sediments are not particularly well washed or sorted but do not resemble greywackes. The flow markings shown in pl. xi, fig. 4 suggest mud flow amount small prominences on the sea floor and also indicate that the floor may have been sloping. These sediments are not unlike those of the clinoform environment of Rich (1951) because of the slumping, but resemble the undoform type with their ripple marks and cross bedding. There is no clear division here and the sediments probably formed on a minor slope in very shallow water.

It is concluded that the chocolate beds were laid down in very shallow water, which may have been terrestrial (lacustrine) or marine under normal climatic conditions in a moderately stable tectonic environment.

COMPOSITE STRATIGRAPHIC COLUMN IN THE MOUNT PLANTAGENET REGION

This composite stratigraphic column is made up of a series of sections taken in various parts of the area as follows: Formations 14 to 12 were measured along Waiaca Creek, 11 and 10 Morgan Creek, 9 Waiaca Creek, 8 Worumba, 7 to 5 Waiaca Creek, 4 to 2 two miles north-west of Yednalue, 1 along Morgan Creek.

The thicknesses in the last portion of the section are approximate, and the beds shown constitute only portion of this formation.

CAMBRIAN

14 POUND SANDSTONE (Cambrian) - - - - - 2800

2200 ft. White quartzite and sandstone.
600 ,, Red sandstone.

PROTEROZOIC

13 CHOCOLATE SLATES - - - - - - - - - 6100

450 ft. Blue, grey and buff limestone.
800 ,, Chocolate slates with interbedded grey limestone.
700 ,, Chocolate slates.
1500 ,, Chocolate slaty quartzite, thinly bedded, showing ripple marks and slumping; and a little pink quartzite.
66 ,, Light grey fused quartzite with current bedding.
2580 ,, Finely-laminated chocolate shales with ripple marks and sun cracks and narrow bands of cross-bedded quartzite.

12 CALCAREOUS SHALES - - - - - - - 1300

in the upper part.
150 ,, Soft grey shale.
45 ,, Laminated siltstone.
210 ,, Soft grey slate.
90 ,, Slaty quartzite.
290 ,, Soft blue slate.

11	OOLITIC LIMESTONE - - - - - - -		(240–300)
	240 ft.	Gritty and oolitic buff limestone.	
10	QUARTZITE FORMATION - - - - - - -		1820
	120 ft.	Blue limestone, becoming siliceous and gritty at the top.	
	1300 „	Blue-grey siltstone showing facies changes along the strike.	
	400 „	Slaty siltstone with varying amounts of argillaceous or arenaceous material.	
9	FLUVIOGLACIAL SLATES - - - - - -		8200
	220 ft.	Blue gritty shales.	
	70 „	Coarse blue-grey grit.	
	970 „	Slates and siltstones with irregular sandy lenses.	
	150 „	Sandstone showing cross bedding.	
	30 „	Slaty siltstone.	
	20 „	Blue quartzite.	
	480 „	Banded blue siltstones.	
	30 „	Quartzite.	
	1765 „	Siltstones and slates, blue to grey in colour, strongly banded and showing cross bedding. There are numerous bands of quartzite about 4″ thick.	
	150 „	Grey quartzite.	
	4235 „	Siltstone and quartzite.	
8	UPPER GLACIAL BEDS - - - - - - - -		1650
	5 ft.	Tillite.	
	500 „	Gritty slate and quartzite.	
	20 „	Tillite.	
	1000 „	Slates, siltstones, grits and gritty slates with erratics.	
	120 „	Tillite with interbedded limestones up to 20 ft. thick.	
7	INTERGLACIAL QUARTZITE - - - - - -		890
	155 ft.	Quartzite.	
	10 „	Coarse angular grit.	
	150 „	Quartzite.	
	150 „	Siltstone.	
	255 „	Gritty quartzite.	
	45 „	Breccia.	
	125 „	Quartzite.	
6	INTERGLACIAL SLATES - - - - - - -		430
	410 ft.	Purple to chocolate siltstone and slates.	
	20 „	Gritty quartzite.	
5	LOWER GLACIAL BEDS - - - - - - - -		3879
	3870 ft.	Quartzites, siltstones, shales with bands of gritty tillite, boulder beds and a little limestone at the base.	
4	CALCAREOUS SILTSTONE - - - - -		approx. 4850
	1000 ft.	Blue calcareous siltstone showing cross-bedding.	
	1500 „	Bluish quartzite with bands of siltstone and limestone.	
	1000 „	Quartzite.	
	350 „	Grey limestone.	
	1000 „	Blue-grey calcareous quartzite and siltstones showing cross-bedding and intraformational slumping.	
3	MAGNESITE-DOLOMITE FORMATION - - - - -		2300
	53 ft.	White flaggy marble.	
	62 „	Soft grey shale.	
	29 „	Coarse white marble.	
	51 „	Grey shale with magnesite pellets.	
	22 „	Dolomitic shale.	
	197 „	Blue cherty dolomite with narrow bands of magnesite.	
	91 „	Laminated dolomite and shale.	
	19 „	Dolomite with white magnesite bands.	

73 ft.	Soft grey shale.
49 „	Dolomite with white magnesite bands.
65 „	Impure shaley dolomite.
48 „	Dolomite.
45 „	Soft dolomitic shales.
41 „	Dolomite and shale.
40 „	Soft shale.
39 „	Dolomite with a little magnesite and grit.
12 „	Impure pellet magnesite.
42 „	Dolomite and shale with a little grit.
15 „	Pellet magnesite.
4 „	Grey dolomitic grit with cross-bedding.
1 „	Coarse pellet magnesite.
59 „	Flaggy blue-grey dolomite with a narrow grit bed.
36 „	Dolomite with narrow bands of crypto-crystalline and pellet magnesite.
90 „	Blue slaty dolomite.
14 „	Dolomite and pellet magnesite.
32 „	Soft bluish shale.
71 „	Blue-grey dolomite.
4 „	Grit with cross bedding.
120 „	Shale with a little dolomite and magnesite.
935 „	Laminated and flaggy blue-grey dolomite and shale.

2 YEDNALUE QUARTZITE - - - - - - 750

150 ft.	Sandstone finely bedded or massive.
25 „	Shale with a little sandstone.
25 „	Somewhat fractured quartzite.
12 „	Shale.
40 „	Shale with narrow quartzite bands.
60 „	Sandy shale.
15 „	Sandstone.
45 „	Shale with a little sandstone.
280 „	Sandstone and quartzite.
95 „	Impure limestone and shale.

1 PHYLLITE–DOLOMITE FORMATION - - - - 2200

300 ft.	Dolomite.
155 „	Blue laminated slates.
35 „	Dolomite.
10 „	Siltstone-quartzite.
1700 „	Impure dolomite.

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MAWSON, D., and SEGNIT, E. R. 1948 Purple Slates of the Adelaide System. Trans. Roy. Soc. S. Aust., **72**, (2)

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ROYAL SOCIETY OF SOUTH AUSTRALIA (INCORPORATED)

Receipts and Payments for the Year ended 30th September, 1951

RECEIPTS

	£ s. d.	£ s. d.
To Balance, 1st October, 1950		64 6 7
„ Subscriptions		211 0 10
„ Subscriptions Associates Fees from F.N.S.		31 15 0
„ Government Grant for Printing, etc.		400 0 0
„ Grant from Agricultural Department		350 0 0
„ Sale of Publications and Reprints:		
University	73 18 11	
Mines Department	71 2 0	
Sundries	63 18 0	
		208 18 11
„ Hire of Rooms		1 7 0
„ Interest		209 0 3
		£1,476 8 7

PAYMENTS

			£ s. d.	£ s. d.
By Transactions (Printing & Publishing Vol. 73, pt. 2, Vol. 74, pt. 1,, Vol. 74, pt. 2				846 14 2
„ Reprints				51 10 0
„ Librarian				33 0 0
„ Printing, etc.				59 13 7
„ Printing Rules - Bylaws				23 12 6
„ Legal Expenses				2 4 6
„ Postage				47 14 4
„ Sundries:				
Lighting			9 1 2	
Insurance			6 12 6	
Cleaning Rooms			18 11 0	
Hire Epidiascope			1 1 0	
Petties			9 12 7	
Associates subscriptions remitted to F.N.S.			31 15 0	
				76 13 3
„ Balances—30th Sept., 1951				
Savings Bank of S.A.			220 18 9	
Aust. and N.Z. Bank Ltd.		129 15 4		
Less Outstanding Chqus	6 8 11			
	1 4 11			
	5 10 0			
	4 0 0			
		17 3 10		
			112 11 6	
„ Cash in Hand			1 16 0	
				335 6 3
				£1,476 8 7

Receipts and Payments for the ENDOWMENT FUND as at 30th September 1951

	£ s. d.	£ s. d.
1950—October 1		
To Balance—		
Aust. Inscribed Stock	6,010 0 0	
Savings Bank of S.A.	62 18 7	
		6,072 18 7
1951—September 30		
To Interest—		
Inscribed Stock	199 14 6	
Savings Bank of S.A.	9 5 9	
		209 0 3
		£6,281 18 10

	£ s. d.	£ s. d.
1951—September 30		
By Revenue Account		209 0 3
Balance:		
Aust. Inscribed Stock	6,010 0 0	
Savings Bank of S.A.	62 18 7	
		6,072 18 7
		£6,281 18 10

Audited and found correct. The Stock and Bank Balances have been verified by certificates from the respective institutions.

F. M. ANGEL
N. ANGEL, A.U.A. Com. } Hon. Auditors

Adelaide, 9th October, 1951.

H. WOMERSLEY, Hon. Treasurer

AWARDS OF THE SIR JOSEPH VERCO MEDAL

1929 Prof. Walter Howchin, F.G.S.
1930 John McC. Black, A.L.S.
1931 Prof. Sir Douglas Mawson, O.B.E., D.Sc., B.E., F.R.S.
1933 Prof. J. Burton Cleland, M.D.
1935 Prof. T. Harvey Johnston, M.A., D.Sc.
1938 Prof. J. A. Prescott, D.Sc., F.A.I.C.
1943 Herbert Womersley, A.L.S., F.R.E.S.
1944 Prof. J. G. Wood, D.Sc., Ph.D.
1945 Cecil T. Madigan, M.A., B.E., D.Sc., F.G.S.
1946 Herbert M. Hale

LIST OF FELLOWS, MEMBERS, ETC.

AS AT 30 MARCH 1951

Those marked with an asterisk (*) have contributed papers published in the Society's Transactions. Those marked with a dagger (†) are Life Members.

Any change in address or any other changes should be notified to the Secretary.

Note—The publications of the Society are not sent to those members whose subscriptions are in arrear.

Date of Election

Honorary Fellows

1945. *Fenner, C. A. E., D.Sc., 42 Alexandra Avenue, Rose Park, Adelaide—Fellow, 1917-45; *Council*, 1925-28; *President*, 1930-31; *Vice-President*, 1928-30; *Secretary*, 1924-25; *Treasurer*, 1932-33; *Editor*, 1934-37.

1949. *Cleland, Prof. J. B., M.D., Dashwood Road, Beaumont, S.A.—*Fellow*, 1895-1949; *Verco Medal*, 1933; *Council*, 1921-26, 1932-37; *President*, 1927-28; 1940-41; *Vice-President*, 1926-27, 1941-42.

Fellows.

1946. Abbie, Prof. A. A., M.D., D.Sc., Ph.D., University of Adelaide.
1951. Aitchison, G. D., B.E., Waite Research Institute (Private Mail Bag), G.P.O., Adelaide.
1927. *Alderman, A. R., Ph.D., D.Sc., F.G.S. , Div. Indus. Chemistry, C.S.I.R.O., Box 4331, G.P.O., Melbourne, Victoria—*Council*, 1937-42.
1951. Anderson, Mrs. S. H., B.Sc., Zoology Dept., University of Adelaide, S.A.
1931. Andrew, Rev. J. R., c/o Methodist Manse, Maitland.
1951. Andrews, J., M.B., B.S., 40 Seafield Avenue, Kingswood, S.A.
1935. *Andrewartha, H. G., M.Agr.Sc., D.Sc., Waite Institute (Private Mail Bag), Adelaide—*Council*, 1950; *Vice-President*, 1950-51; *President*, 1951-.
1935. *Andrewartha, Mrs. H. V., B.Agr.Sc., M.S., (nee H. V. Steele), 29 Claremont Avenue, Netherby, S.A.
1929. *Angel, F. M., 34 Fullarton Road, Parkside, S.A.
1939. *Angel, Miss L. M., M.Sc., c/o University of Adelaide.
1945. *Bartlett, H. K., L.Th., 15 Claremont Avenue, Netherby, S.A.
1950. Beasley, A. K., Harris Street, Marden, S.A.
1950. Beck, R. G., B.Ag.Sc., R.D.A., Linewood Park, Mittel, S.A.
1932. Begg, P. R., D.D.Sc., L.D.S., Shell House, 170 North Terrace, Adelaide.
1928. Best, R. J., D.Sc., F.A.C.I., Waite Institute (Private Mail Bag), Adelaide.
1934. Black, E. C., M.B., B.S., Magill Road, Tranmere, Adelaide.
1950. Bonnin, N. J., M.B., B.S., F.R.C.S. (Eng.), F.R.A.C.S., 144 Hill Street, North Adelaide, S.A.
1945. *Bonython, C. W., B.Sc., A.A.C.I., Romalo House, Romalo Avenue, Magill, S.A.
1940. Bonython, Sir J. Lavington, B.A. (Camb.), 263 East Terrace, Adelaide.
1945. *Boomsma, C. D., M.Sc., B.Sc.For., 2 Celtic Avenue, South Road Park, S.A.
1947. Bowes, D. R., Ph.D., M.Sc., D.I.C., F.G.S., 51 Eton Street, Malvern.

Date of Election.

1939. BROOKMAN, Mrs. R. D. (nee A. Harvey), B.A., Meadows, S.A.
1945. BROUGHTON, A. C., Farina, S.A.
1948. BROWNING, T. O., B.Sc. (Syd.), Waite Institute (Private Mail Bag), Adelaide.
1944. *BURBIDGE, MISS N. T., M.Sc., C.S.I.R.O., Div. Plant Industry, P.O. Box 109, Canberra, A.C.T.
1923. BURDON, R. S., D.Sc., University of Adelaide—*Council*, 1946.
1922. *CAMPBELL, T. D., D.D.Sc., D.Sc., Dental Dept., Adelaide Hospital, Adelaide—*Council*, 1928-32, 1935, 1942-45; *Vice-President*, 1932-34; *President*, 1934-35.
1944. CASSON, P. B., B.Sc., For. (Adel.), 8 Benjafield Terrace, New Town, Hobart.
1951. CHITTLEBOROUGH, R. G., B.Sc., c/o C.S.I.R.O., Div. of Fisheries, 1 Museum Street, Perth, W.A.
1929. CHRISTIE, W., M.B., B.S., Education Department, Social Services, 51 Pirie Street Adelaide—*Treasurer*, 1933-38.
1950. COALSTAD, S. E., B.Sc., 6 Hampton Street, Hawthorn, S.A.
1949. COLLIVER, F. S., Geology Department, University of Queensland.
1930. *COLQUHOUN, T. T., M.Sc., 10 French Street, Netherby, S.A.—*Secretary*, 1942-43.
1907. *COOKE, W. T., D.Sc., A.A.C.I., 4 South Terrace, Kensington Gardens, S.A.—*Council*, 1938-41; *Vice-President*, 1941-42, 1943-44; *President*, 1942-43.
1942. *COOPER, H. M., 51 Hastings Street, Glenelg, S.A.
1929. *COTTON, B. C., S.A. Museum, Adelaide—*Council*, 1943-46, 1948-49; *Vice-President*, 1949-50, 1951; *President*, 1950-51.
1951. DAVIDSON, A. C. L., Ph.D., B.Sc., Waite Research Institute, Private Mail Bag, G.P.O., Adelaide.
1924. DE CRESPIGNY, SIR C. T. C., D.S.O., M.D., F.R.C.P., 219 North Terrace, Adelaide.
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1941. DICKINSON, S. B., M.Sc., 52 Burnside Road, Kensington.—*Council*, 1949-51; *Vice-President*, 1951-.
1930. DIX, E. V., Hospitals Department, Rundle Street, Adelaide, S.A.
1944. DUNSTONE, S. M. L., M.B., B.S., 124 Payneham Road, St. Peters, Adelaide.
1931. DWYER, J. M., M.B., B.S., 105 Port Road, Hindmarsh, S.A.
1933. *EARDLEY, MISS C. M., M.Sc., University of Adelaide—*Council*, 1943-46.
1945. *EDMONDS, S. J., B.A., M.Sc., 56 Fisher Terrace, Mile End, S.A.
1902. *EDQUIST, A. G., 19 Farrell Street, Glenelg, S.A.—*Council*, 1949-.
1944. FERRES, MISS H. M., M.Sc., 8 Taylor's Road, Mitcham, S.A.
1927. *FINLAYSON, H. H., 305 Ward Street, North Adelaide—*Council*, 1937-40.
1951. FISHER, R. H., 265 Goodwood Road, Kings Park, S.A.
1923. *FRY, H. K., D.S.O., M.D., B.S., B.Sc., F.R.A.C.P., Town Hall, Adelaide—*Council*, 1933-37; *Vice-President*, 1937-38, 1939-40; *President*, 1938-39.
1951. FULTON, COL. D., C.M.G., C.B.E., Aldgate, S.A.
1932. *GIBSON, E. S. H., M.Sc., 297 Cross Roads, Clarence Gardens, Adelaide.
1927. GODFREY, F. K., Box 951H, G.P.O., Adelaide.
1935. †GOLDSACK, H., Coromandel Valley, S.A.
1925. †GOSSE, SIR JAMES H., Gilbert House, Gilbert Place, Adelaide.
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1933. GREAVES, H., 12 Edward Street, Glynde, S.A.
1951. GREEN, J. W., 4 Holden Street, Kensington Park, S.A.
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1944. GUPPY, D. J., B.Sc., Mineral Resources Survey, Canberra, A.C.T.
1922. *HALE, H. M., Director S.A. Museum, Adelaide—*Verco Medal*, 1946; *Council*, 1931-34, 1950-; *Vice-President*, 1934-36, 1937-38; *President*, 1936-37; *Treasurer*, 1938-1950.
1949. HALL, D. R., Mern Merna, via Quorn, S.A.
1946. *HARDY, MRS. J. E. (nee A. C. Beckwith), M.Sc., Box 62, Smithton, Tas.
1944. HARRIS, J. R., B.Sc., 94 Archer Street, North Adelaide, S.A.
1947. HENDERSON, D. L. W., P.M.B., 20 Bourke, N.S.W.
1944. HERRIOT, R. I., B.Agr.Sc., Soil Conservator, Dept. of Agriculture, S.A.
1951. HOCKING, L. J., 57 Marino Parade, Seacliff, S.A.
1949. HOLLOWAY, B. W., B.Sc., 33 Kyre Avenue, Kingswood, S.A.
1924. *HOSSFELD, P. S., M.Sc., 132 Fisher Street, Fullarton, S.A.
1950. HOWARD, P. F., B.Sc., c/o Great Western Consolidated, Bullfinch, W.A.
1944. HUMBLE, D. S. W., 238 Payneham Road, Payneham, S.A.
1947. HUTTON, J. T., B.Sc., 18 Emily Avenue, Clapham.
1928. IFOULD, P., Kurralta, Burnside, S.A.
1942. JENKINS, C. F. H., Department of Agriculture, St. George's Terrace, Perth, W.A.

Date of Election.

1918. *JENNISON, REV. J. C., 7 Frew Street, Fullarton, S.A.
1945. *JESSUP, R. W., M.Sc., 3 Alma Road, Fullarton, S.A.
1910. *JOHNSON, E. A., M.D., M.R.C.S., 1 Baker Street, Glenelg.
1950. JOHNS, R. K., B.Sc., Department of Mines, Flinders Street, Adelaide, S.A.
1951. KALAROVIC, D., B.A.Sc. (Min.), 22 Grandview Road, Toorak Gardens, S.A.
1951. KESTING, N. G., Dept. Arts and Ed., P.A.C. Preparatory School, 3 Hartley Road, Brighton, S.A.
1939. †KHAKHAR, H. M., Ph.D., M.B., F.R.G.S., Khakhar Buildings, C.P. Tank Road, Bombay, India.
1949. *KING, D., M.Sc., 44 Angwin Avenue, Blair Athol, S.A.
1933 *KLEEMAN, A. W., M.Sc., University of Adelaide—*Secretary*, 1945-48; *Vice-President*, 1948-49, 1950-51; *President*, 1949-50.
1922. LENDON, G. A., M.D., B.S., F.R.C.P., A.M.P. Building, King William Street, Adelaide.
1948. LOTHIAN, T. R. N., N.D.H. (N.Z.), Director, Botanic Gardens, Adelaide.
1949. LOWER, H. F., 7 Avenue Road, Highgate, S.A.
1931. *LUDBROOK, MRS. W. V. (nee N. H. Woods), M.A., Elimatta Street, Reid, A.C.T.
1948. MCCULLOCH, R. N., M.B.E., B.Sc. (Oxon.), B.Agr.Sci. (Syd.), Roseworthy Agricultural College, S.A.
1938. MADDERN, C. B., B.D.S., D.D.Sc., Shell House, North Terrace, Adelaide.
1932. MANN, E. A., C/o Bank of Adelaide, Adelaide.
1939. MARSHALL, T. J., M.Agr.Sc., Ph.D., Waite Institute (Private Mail Bag), Adelaide—*Council*, 1948-.
1905. *MAWSON, PROF. SIR DOUGLAS, O.B.E., D.Sc., B.E., F.R.S., University of Adelaide—*Verco Medal*, 1931; *President*, 1924-25, 1944-45; *Vice-President*, 1923-24, 1925-26; *Council*, 1941-43.
1950. MAY, L. H., B.Sc., 691 Esplanade, Grange, S.A.
1920. MAYO, THE HON. MR. JUSTICE, LL.B., K.C., Supreme Court, Adelaide.
1950. MAYO, G. M. E., B.Ag.Sc., Waite Institute (Private Mail Bag), Adelaide, S.A.
1943. MCCARTHY, MISS D. F., B.A., B.Sc., 70 Halton Terrace, Kensington Park.
1945. †*MILES, K. R., D.Sc., F.G.S., Mines Department, Flinders Street, Adelaide.
1951. MILES, J. A. K., M.A., M.B., B.Chir. (Cant.), 48 Gladys Street, Edwardstown, S.A.
1939. MINCHAM, V. H., Hammond, S.A.
1925. †MITCHELL, PROF. SIR W., K.C.M.G., M.A., D.Sc., Fitzroy Ter., Prospect, SA.
1933. MITCHELL, PROF. M. L., M.Sc., University, Adelaide.
1951. MITCHELL, F. J., c/o The South Australian Museum, North Terrace, Adelaide.
1938. MOORHOUSE, F. W., M.Sc., Chief Inspector of Fisheries, Flinders Street, Adelaide.
1936. *MOUNTFORD, C. P., 25 First Avenue, St. Peters, Adelaide.
1944. MURRELL, J. W., Engineering and Water Supply Dept., Port Road, Thebarton, S.A.
1944. NEAL-SMITH, C. A., B.Agr.Sci., 16 Gooreen Street, Reid, Canberra, A.C.T.
1944. NINNES, A. R., B.A., 62 Sheffield Street, Malvern, S.A.
1945. *NORTHCOTE, K. H., B.Agr.Sc., A.I.A.S., Waite Institute (Private Mail Bag), Adelaide.
1930. OCKENDEN, G. P., B.A., c/o Flinders Street Practising School, Flinders St., Adelaide.
1947. *OPHEL, I. L., 65 Fifth Avenue, St. Peters, S.A.
1913. *OSBORN, PROF. T. G. B., D.Sc., Department of Botany, Oxford, England—*Council*, 1915-20, 1922-24; *President*, 1925-26; *Vice-President*, 1924-25, 1926-27.
1937. *PARKIN, L. W., M.Sc., c/o North Broken Hill Mining Co., Melbourne, Victoria.
1949. PARKINSON, K. J., B.Sc., 8 Mooreland Avenue, Beverley, S.A.
1945. PATTISON, G., 68 Partridge Street, Glenelg, S.A.
1929. PAULL, A. G., M.A., B.Sc., 10 Milton Avenue, Fullarton, S.A.
1926. *PIPER, C. S., D.Sc., Waite Institute (Private Mail Bag), Adelaide—*Council*, 1941-43; *Vice-President*, 1943-45, 1946-47; *President*, 1945-46.
1948. POWRIE, J. K., B.Sc., C.S.I.R.O., Division of Biochemistry, University, Adelaide.
1947. POYNTON, J. O., M.D., M.A., Ch.B., M.R.C.S., L.R.C.P., Institute Medicine, Vet Science, Frome Road, Adelaide.
1949. PRAITE, R. G., 81 Park Terrace, North Unley, S.A.
1925. *PRESCOTT, PROF. J. A., C.B.E., D.Sc., A.I.C., Waite Institute (Private Mail Bag), Adelaide—*Verco Medal*, 1938; *Council*, 1927-30, 1935-39; *Vice-President*, 1930-32; *President*, 1932-33.
1926. PRICE, A. G., C.M.G., M.A., Litt.D., F.R.G.S., 46 Pennington Terrace, North Adelaide.
1945. PRYOR, L. D., M.Sc., Dip.For., 32 La Perouse Street, Griffith, N.S.W.
1950. *RATTIGAN, J. H., B.Sc., Bureau of Mineral Resources, Melbourne Building, Canberra, A.C.T.
1951. RAYSEN, P., B.Sc., Box 111, Bordertown, S.A.
1944. RICEMAN, D. S., M.Sc., B.Agr.Sc., C.S.I.R.O., Division of Nutrition, Adelaide.

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1947. Riedel, W. R., B.Sc., Oceanographic Institute, Gottenburg, Sweden.
1948. *Rimes, G. D., B.Sc., 24 Winston Avenue, Clarence Gardens, S.A.
1947. Rix, C. E., 42 Waymouth Avenue, Glandore, S.A.
1946. *Robinson, E. G., M.Sc., 42 Riverside Drive, Sudbury, Ontario, Canada.
1951. Rossel, L. D., c/o High School, Port Pirie, S.A.
1951. Rowe, S. A., 22 Shelley Street, Firle, S.A.
1951. Rowe, S. E., B.Sc., 22 Shelley Street, Firle, S.A.
1950. Rudd, Prof. E. A., B.Sc., A.M., University, Adelaide, S.A.
1945. Rymill, J. R., Old Penola Estate, Penola, S.A.
1944. *Sandars, Miss D. F., M.Sc., University of Queensland, Brisbane, Queensland.
1950. Saunders, F. L., 79 Winchester Street, Malvern, S.A.
1933. Schneider, M., M.B., B.S., 175 North Ter., Adelaide.
1951. Scott, T. D., B.Sc., c/o S.A. Museum, North Terrace, Adelaide, S.A.
1946. *Segnit, E. R., M.Sc., C.S.I.R.O., Division of Industrial Chemistry, Box 4331, G.P.O, Melbourne, Victoria.
1924. *Segnit, R. W., M.A., B.Sc., Engineering and Water Supply Department, Victoria Square, Adelaide—*Secretary,* 1930-35; *Council,* 1937-38; *Vice-President,* 1938-39, 1940-41; *President,* 1939-40.
1925. *Sheard, H., Port Elliot, S.A.
1936. *Sheard, K., Fisheries Research Div. C.S.I.R.O., University of W.A., Nedlands, W.A.
1945. Shepherd, J. H., M.Sc., B.A., c/o Anglo-Westralian Mining Pty. Ltd.
1934. Shinkfield, R. C., Salisbury, S.A.
1924. Simpson, F. N., Pirie Street, Adelaide.
1949. Simpson, D. A., M.B., B.S., 42 Lockwood Road, Burnside, S.A.
1941. *Smith, T. Langford-, B.Sc., Department of Post-War Reconstruction, Canberra, A.C.T.
1941. Southcott, R. V., M.B., B.S., D.T.M. & H., 13 Jasper Street, Hyde Park—*Council,* 1948-51; *Treasurer,* 1951-.
1936. Southwood, A. R., M.D., M.S. (Adel.), M.R.C.P., Wootoona Ter., Glen Osmond, S.A.
1947. *Specht, R. L., M.Sc., 15 Main Road, Richmond, S.A.—*Council,* 1951-.
1936. †*Sprigg, R. C., M.Sc., Mines Department, Flinders Street, Adelaide.
1951. Steadman, Rev. W. R., 1 De Saumarez Street, Kensington Park, S.A.
1947. Spurling, M. B., B.Ag.Sc., Agricultural College, Roseworthy, S.A.
1949. *Spry, A. H., B.Sc., 63 LeFevre Terrace, North Adelaide, S.A.
1938. *Stephens, C. G., D.Sc., Waite Institute (Private Mail Bag), Adelaide.
1935. Strickland, A. G., M.Agr.Sc., 11 Wootoona Terrace, Glen Osmond, S.A.—*Council,* 1947.
1932. Swan, D. C., M.Sc., Waite Institute (Private Mail Bag), Adelaide—*Secretary,* 1940-42; *Vice-President,* 1946-47, 1948-49; *President,* 1947-48.
1948. Swann, F. J. W., 38 Angas Road, Lower Mitcham, S.A.
1951. Swirski, P., M.Ag.Sc., 22a Henry Street, Croydon, S.A.
1934. Symons, I. G., 35 Murray Street, Lower Mitcham, S.A.—*Editor,* 1947-.
1929. *Taylor, J. K., B.A., M.Sc., Waite Institute (Private Mail Bag), Adelaide—*Council,* 1940-43, 1947-50; *Librarian,* 1951-.
1950. Taylor, G. H., B.Sc., Department of Mines, Old Legislative Council Building, North Terrace, Adelaide, S.A.
1948. *Thomas, I. M., M.Sc. (Wales), University, Adelaide—*Secretary,* 1948-50; *Council,* 1950-.
1938. *Thomas, Mrs. I. M. (nee P. M. Mawson), M.Sc., 36 King Street, Brighton.
1940. Thomson, Capt. J. M., 135 Military Road, Semaphore South, S.A.
1923. *Tindale, N. B., B.Sc., South Australian Museum, Adelaide—*Secretary,* 1935-36; *Council,* 1946-47; *Vice-President,* 1947-48, 1949-50; *President,* 1948-49.
1945. Tiver, N. S., M.Sc., B.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide.
1937. *Trumble, Prof. H. C., D.Sc., M.Agr.Sc., Waite Institute (Private Mail Bag), Adelaide—*Council,* 1942-1945; *Vice-President,* 1945-46, 1947-48; *President,* 1946-47.
1925. Turner, D. C., Brookman Buildings, Grenfell Street, Adelaide.
1950. Vietch, S. T., Port Lincoln, S.A.
1912. *Ward, L. K., I.S.O., B.A., B.E., D.Sc., 22 Northumberland Avenue, Tusmore—*Council,* 1924-27, 1933-35; *Vice-President,* 1927-28; *President,* 1928-30.
1941. *Wark, D. C., M.Agr.Sc., Div. Plant Industry, C.S.I.R.O., Canberra, A.C.T.
1936. Waterhouse, Miss L. M., 35 King Street, Brighton, S.A.
1939. *Weeding, Rev. B. J., 5 York Street, Henley Beach.
1949. *Wegener, C. F., B.Sc., Department Mines, Flinders Street, Adelaide, S.A.
1946. Whittle, A. W. G., B.Sc., Mines Department, Flinders Street, Adelaide.
1950. Williams, L. D., "Dumosa," Meningie, S.A.

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1946. *WILSON, A. F., M.Sc., University of W.A., Nedlands, W.A.
1938. *WILSON, J. O., C.S.I.R.O., Division of Nutrition, Adelaide.
1930. *WOMERSLEY, H., F.R.E.S., A.L.S. (*Hon. causa*), S.A. Museum, Adelaide—*Verco Medal*, 1943; *Secretary*, 1936-37; *Editor*, 1937-43, 1945-47; *President*, 1943-44, *Vice-President*, 1944-45; *Rep. Fauna and Flora Protection Committee*, 1945; *Treasurer*, 1950-51.
1944. *WOMERSLEY, H. B. S., M.Sc., University of Adelaide.
1944. WOMERSLEY, J. S., B.Sc., Lae, New Guinea.
1923. *WOOD, PROF. J. G., D.Sc., Ph.D., University of Adelaide—*Verco Medal*, 1944; *Council*, 1938-40; *Vice-President*, 1940-41, 1942-43; *Rep. Fauna and Flora Board*, 1940-; *President*, 1941-42; *Council*, 1944-48.
1950. WOODARD, G. D., 20 Kensington Road, Leabrook, S.A.
1943. WOODLANDS, HAROLD, Box 989 H, G.P.O., Adelaide.
1945. WORTHLEY, B. W., B.A., M.Sc., A. Inst. P., University, Adelaide.
1948. *WYMOND, A. P., B.Sc., 4 Woodley Road, Glen Osmond, S.A.
1949. YEATES, J. N., L.S., A.M.I.E., A.M.I.M.E., Richards Buildings, 99 Currie Street, Adelaide, S.A.
1944. ZIMMER, W. J., Dip.For., F.L.S. (Lon.), 7 Rupert Street, Footscray West, W.12, Vic.

GENERAL INDEX

[Generic and specific names in italics indicate that the forms described are new to science.]

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